



Airspace Systems Program

NextGen-Airspace Project

FY2009 Project Plan

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For External Release

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1. NEXTGEN-AIRSPACE PROJECT PLAN OVERVIEW

1.1 Introduction

1.1.1 Purpose

This document describes the plan for the management and execution of the NextGen-Airspace Project (hereafter referred to as “the Project”) of the NASA Airspace Systems Program (hereafter referred to as “the Program”).

The NASA *Airspace Systems Program Plan*, approved by the Associate Administrator of the Aeronautics Research Mission Directorate (ARMD), covers the Airspace Systems Program and two projects: the NextGen-Airspace Project and the NextGen-Airportal Project. Each year, the NextGen-Airspace Project develops a project plan in response to guidance from the Program and from guidelines in the *Airspace Systems Program Plan* and *NASA Research and Technology Development Management Requirements* described in NPR 7120.8, specifically “Chapter 5, R & T Portfolio Project Requirements.” In the formulation phase of the Project, research and technology needs were established and a technical approach to address those needs was initiated. Funding levels and a management approach to oversee implementation of the Project were also established. In April 2006, the Project submitted a formal research proposal¹ to the Program and ARMD; in May 2006, the proposal was approved. Throughout the execution phase of the Project, an annual project plan is developed to address how the Project will execute the proposal strategy in a given year. An initial project plan was submitted and approved for FY2007. An update was subsequently submitted for FY2008. This document, titled *NextGen-Airspace Project FY2009 Project Plan* (hereafter referred to as “FY2009 Project Plan” or “the Project Plan”) represents an update to the *NextGen-Airspace Project FY2008 Project Plan*.

The FY2009 Project Plan describes a significant realignment of the NextGen-Airspace Project to address the following: (1) new milestones in FY2012 – 2014; (2) the Project’s alignment with the Joint Planning and Development Office (JPDO) *Next Generation Air Transportation System Integrated Work Plan (Version 0.2/1.0)*; (3) a reduction in Project overhead, where appropriate, and (4) an improvement in the Project funding profile. As in previous versions of the Project Plan, the FY2009 Project Plan discusses the NextGen-Airspace Project within the context of NASA’s role in ATM research in support of NextGen, as defined by the JPDO.

1.1.2 Background

Congress established the multi-agency JPDO in 2003 to develop the vision for the 2025 Next Generation Air Transportation System (NextGen) and to define the research required to enable it.

¹ Next Generation Air Transportation System (NGATS) Air Traffic Management (ATM)-Airspace Project Approved Project Proposal, May 24, 2006, by Harry Swenson, Richard Barhydt, and Michael Landis.

NASA is one of seven agency partners contributing to the effort.² Accordingly, in FY2007, NASA's ARMD realigned the Airspace Systems Program to "directly address the fundamental research needs of the Next Generation Air Transportation System... in partnership with the member agencies of the JPDO."³ The Program subsequently established the NextGen-Airspace Project and the NextGen-Airportal Project to meet this objective.

1.2 Overview

The NextGen-Airspace Project is developing and exploring fundamental concepts and integrated solutions that address the optimal allocation of ground and air automation technologies necessary to enable NextGen, as defined by the JPDO. The Project is focusing NASA's technical expertise and world-class facilities to address the question of where, when, how, and the extent to which automation can be applied to the safe and efficient movement of aircraft through the NAS. **Figure 1** illustrates the NextGen-Airspace Project concept.



Figure 1. The NextGen Airspace Project Concept

² JPDO partners include Department of Commerce, Department of Defense, Department of Homeland Security, Department of Transportation, the Federal Aviation Administration, NASA, and the White House Office of Science and Technology Policy.

³ NASA's New Aeronautics Research Program, 45th AIAA Aerospace Sciences Meeting & Exhibit, Dr. Lisa Porter, Associate Administrator for Aeronautics, 11 January 2007.

Specific research technical goals include:

- Increase capacity through dynamic allocation of airspace structure and controller resources.
- Effectively allocate demand through departure time management, route modification, adaptive speed control, etc., in the presence of uncertainty.
- Increase capacity through higher levels of automation for separation management, scheduling sequencing, merging, and spacing.
- Develop accurate trajectory predictions that are interoperable with aircraft flight management systems and account for prediction uncertainty growth and propagation.
- Quantify the performance-enhancing effects of emerging airborne technologies.
- Show system level performance of all NASA technologies.
- Develop computer modeling and analysis tools capable of evaluating the systematic impact of NextGen research.

1.3 FY 2009 Objectives

On December 9, 2008, the Airspace Systems Program Director approved the Project's realignment plan as developed by the Associate Principal Investigator (APIs), and the Project Scientist (PS), Project Manager (PM) and Principal Investigator (PI) and presented by the PI to the Program. Based on the authorization to proceed with the realignment, in FY2009 the Project will focus on completion and implementation of the NextGen-Airspace Project realignment, an effort that began in FY2008 in response to a significant improvement in the budget profile.⁴ The realignment first addressed adjustments to the FY2007 Project Plan for FY2009-FY2011 to accommodate a \$17M budget augmentation for FY2008. The realignment recently addressed new work to take advantage of a \$150M budget increase for FY2009–FY2014.

1.3.1 FY2008 Transition

FY2008 was a transition year for the Project with a primary objective of realigning its research to take advantage of a \$17M Congressional budget augmentation. In response, the Project realigned parts of the Project for FY2009-FY2011. Specifically, the Project:

- Initiated research and development in the following new areas :
 - Integrating weather research into ATM applications and into ATM modeling tools
 - Expanding simulation capabilities for airborne separation assurance
 - Developing off-nominal scenarios

⁴ The Project and the Airspace Systems Program successfully justified a budget increase of more than \$150M together with a workforce increase, effective FY2009 through FY2014. At the same time, the Project received a \$17M Congressional budget augmentation for FY2008. The Project subsequently initiated a realignment process to adjust its technical work to make use of the increased funding.

- Established, with the FAA, three Research Transition Teams (RTTs) to help identify research and development needed for NextGen implementation and to ensure that the research is conducted and effectively transitioned to the implementing agency. RTTs that the Project is supporting are:
 - Efficient Flow into Congested Airspace (near- and mid-term) RTT
 - Multi-Sector Planner (mid-term) RTT
 - Dynamic Airspace Configuration (mid and far-term) RTT

1.3.2 Recent Adjustments

Recent adjustments focused on re-planning and re-scoping new work in the out-years and restructuring two Research Focus Areas (RFAs). In particular, the Project absorbed milestones and resources from the Performance Based Services (PBS) Research Focus Area (RFA) into the Separation Assurance (SA) RFA and eliminated PBS as a separate RFA. The Project is also currently considering the formal, direct integration of milestones in the Airspace Super Density Operations (ASDO) RFA with milestones in the Coordinated Arrival Departure Management (CADOM) RFA of the NextGen-Airportal Project. In other aspects of the realignment process, the Project accomplished the following:

- Established new milestones for FY2012 – FY2014 based on available budget
- Ensured full alignment (where NASA is responsible) with NextGen research needs, commitments, efforts, and resources, as defined in the JPDO's *Next Generation Air Transportation System Integrated Work Plan: A Functional Outline, Version 0.2/1.0*
- Modified FY2009-FY2011 milestones and project structure based on lessons learned in the first two years of the Project
- Reduced overhead in the Project by eliminating PBS as a separate RFA
- Re-evaluated milestone metrics for clarity and appropriateness to the technical scope of the Project
- Established milestone exit criteria for all milestones

1.3.3 JPDO Alignment

The Project's research agenda is aligned with the JPDO's research needs, commitments, efforts, and resources as defined in the *Next Generation Air Transportation System Integrated Work Plan: A Functional Outline, Version 0.2/1.0* and will conduct research activities in FY2009 according to that agenda. Of the 163 NextGen research and development objectives defined by the JPDO, the NextGen-Airspace Project directly contributes to 44 needs. In addition, Project resources directly align with NextGen research and development.⁵

⁵ NASA's Aeronautics Research in Support of NextGen, Akbar Sultan, Technical Integration Manager, Airspace Systems Program, April 10, 2008.

1.4 Technical Approach

The NextGen-Airspace Project is conducting research and development to extend the state-of-the-art in the foundational areas of computer science, software engineering, applied physics, mathematics, and human factors/automation design and their application to NextGen, as defined by the JPDO. The Project follows a four-level approach to planning and conducting research. The four levels are as follows: (1) conduct foundational research to further our fundamental understanding of the underlying physics (which includes mathematics, chemistry, etc) and our ability to model that physics; (2) leverage the foundational research to develop technologies and computational tools focused on discipline-based solutions; (3) integrate those tools and technologies to develop multi-disciplinary solutions; and (4) address the system-level challenges with system-level optimization, assessment, and technology integration.

The Project is conducting research at all four levels. Foundational research planned for Levels 1 and 2 is being conducted in-house, with some work being done by the external community in areas where NASA needs to enhance its core capabilities. For research at Levels 3 and 4, the Project is collaborating with industry and other U.S. government agencies to develop system-level capabilities that will allow civilian and military partners to develop revolutionary systems to meet their needs.

1.4.1 Research Focus Areas

The NextGen-Airspace Project is conducting research and development on the efficient utilization of emerging ground, and airborne technologies in the airspace to enable NextGen. Accordingly, researchers at NASA Ames Research Center (ARC), NASA Langley Research Center (LaRC), together with researchers in the external community at universities and in industry, are developing, testing, simulating, and (where appropriate) demonstrating advanced concepts, capabilities, and technologies. The work is organized into the following six RFAs:

- **Trajectory Prediction, Synthesis, and Uncertainty (TPSU).** TPSU is focused on providing accurate trajectory predictions that are interoperable with aircraft flight management system (FMS) trajectory generations using prediction uncertainty growth and propagation.
- **Dynamic Airspace Configuration (DAC).** DAC is focused on a new operational paradigm in ATM that seeks to modify static airspace resources (controllers/structure) by temporally increasing capacity based on the movement of resources.
- **Traffic Flow Management (TFM).** TFM is focused on modifying airspace/airports capacity by using multiple optimization techniques to adjust demand through departure times, route modification, adaptive speed control, etc., in the presence of uncertainty.
- **Separation Assurance (SA).** SA is addressing airspace capacity barriers arising from human workload issues related to responsibility for maintaining separation assurance by utilizing sequential processing of sequence and merging with separation for transition and cruise airspace.
- **Airspace Super Density Operations (ASDO).** ASDO is addressing airspace capacity barriers due to human workload/responsibility for separation assurance by utilizing

simultaneous sequencing, spacing, merging, and de-confliction for terminal airspace with nearby runway thresholds.

- **System-Level Design, Analysis, and Simulation Tools (SLDAST).** SLDAST is focused on integrated performance assessments interaction studies across RFAs, and supporting capabilities such as scenario metrics and assumptions.

DAC and TFM are key to the fundamental research purpose of addressing the demand/capacity imbalance problem in the safest, most equitable and efficient manner possible. SA and ASDO are key to increasing capacity and efficiency of airspace operations. TPSU and SLDAST are crosscutting elements that support the key functional thrusts.

1.4.1.1 Trajectory Prediction, Synthesis, and Uncertainty

Transitioning ATM from airspace-based to trajectory-based operations (TBO) represents a significant historic alignment of NAS users with Air Traffic Service Providers (ATSPs) and will enable a more efficient ATM system that better accommodates user-preferred operations. Currently, user operations (e.g., pilots, airline operational control centers) are trajectory-oriented while ATSPs are airspace-oriented (e.g., geographically and spatially). The expected benefits of this transition include the following: (1) more efficient use of airspace, (2) better accommodation of user preferences, (3) increased system capacity through a reduction in human operator workload, (4) increased trajectory predictability, allowing precise use of all NAS capacity, and (5) the best use of deterministic and stochastic information over appropriate planning intervals. The concept of four-dimensional (4D: position [latitude, longitude, altitude] and time) control is the fundamental basis behind ATM trajectory prediction. TPSU research in the NextGen-Airspace Project is focusing on two areas:

- **Fundamental trajectory modeling.** The current state-of-the-art for 4D TBO is limited to specialized areas in air traffic control, i.e., time-based arrival metering, en-route conflict detection, and modern flight management systems (FMSs). TPSU trajectory modeling/prediction research is providing common trajectory prediction algorithms and components together with the trajectory modeling and synthesis technologies needed to support cutting-edge research concepts.
- **Estimating and accommodating trajectory prediction uncertainty.** Trajectory prediction uncertainty derives from multiple sources—e.g., an automation system must have detailed knowledge of the aircraft's performance characteristics, operating procedures, and pilot intent in order to accurately predict a trajectory. Environmental factors (e.g., wind and convective weather systems), procedural assumptions (e.g., crew-dependent procedures for top-of-descent maneuver or approaching the runway), and variances in RNP (Required Navigation Performance) also generate trajectory prediction uncertainty. All of these sources of uncertainty can be mitigated to a degree, and yet some uncertainty will remain. TPSU research in this area is addressing (1) accurately estimating prediction uncertainty and devising mechanisms by which it can be accommodated in decision-making, particularly in the area of conflict management and (2) dynamically predicting uncertainty for use by stochastic-based automation in mitigating its impact.

1.4.1.2 Dynamic Airspace Configuration

ATM employs capacity and demand management techniques to predict and mitigate air traffic demand/capacity mismatches and balance capacity with demand. In NextGen, as defined by the JPDO, demand management will be allocated to the TFM function. Capacity management will be allocated, in part, to the DAC function, a new operational paradigm in ATM. The goal of DAC research is to better serve users' needs by tailoring the availability and capacity of the airspace and promptly communicating its status to users. The fundamental objective of DAC is to provide flexibility where possible and structure where necessary by providing strategic airspace organization and dynamic adjustments as necessary to accommodate changing demand. The primary input to DAC will be regularly updated projections of aggregate demand and equipage characteristics. DAC is expected to include the following capabilities:

- Dynamically manage the allocation and de-allocation of airspace for military and special uses.
- Temporarily instantiate high-density airspace corridors, low-density general-use zones and/or any other class of airspace to best service aggregate user demand.
- "Flex" airspace boundaries to balance projected airspace complexity.
- Temporarily restrict airspace access based upon performance standards to more equitably ration oversubscribed resources.
- Provide flexibility to users where possible.

The DAC capability is dependent upon two enablers: (1) a new NAS infrastructure that supports flexible staffing of NAS, and (2) a metric that aptly projects airspace complexity (which TFM research is exploring). The primary output of DAC will be a reconfigured airspace structure tuned, to the extent feasible, to accommodate aggregate user demand. The time horizon within which traffic managers could be expected to reconfigure airspace ranges from months, to days, to hours.

1.4.1.3 Traffic Flow Management

The primary function of TFM is to identify and resolve any imbalances in the demand and supply of airspace, runways, and other NAS resources. In NextGen, as defined by the JPDO, TFM must accommodate three times more traffic than today while accommodating a diverse traffic mix comprised of airline operations, air taxi operations, general aviation, and unmanned air vehicles. Advanced TFM will also be a key element of the evaluator in NextGen, enabled by 4D trajectory-based operations for optimal utilization of the prevailing airspace and air portal configuration. In pursuit of these aims, the NextGen-Airspace Project is focusing on four areas:

- **Advanced TFM concepts.** Researchers are focusing on the development of advanced TFM techniques that contribute to the goal of tripling NAS capacity by leveraging key features of NextGen, such as 4D trajectory-based operations, performance-based operations, automated separation assurance, and super-density operations. The output of this focus area is a baseline evaluator concept of operations that describes the composition and architecture of TFM functions as well as their temporal and geographic scope.

- **Collaborative decision making in TFM.** Researchers are focusing on the development of a methodology for incorporating user preferences into traffic flow management, building on prior research completed. The outputs of this focus area are algorithms, procedures, and protocols for fully integrating Collaborative Decision Making (CDM) into the TFM process.
- **Weather impact on TFM.** Researchers are focusing on the development of probabilistic models to forecast demand and capacity of NAS resources (e.g., airspace and runways). The outputs of this focus area are probabilistic models/algorithms, and weather product requirements, for improved predictions of NAS resource demand/supply under uncertainty.
- **Simulation and evaluation of TFM concepts.** Researchers are focusing on the development of prototype tools to implement advanced TFM concepts utilizing 4D trajectories, and the implementation of various in a NAS simulation environment such as the Future ATM Concept Evaluation Tool (FACET). The output of this focus area is a suite of advanced TFM tools integrated into a simulation test bed. In NextGen, advanced TFM will be a key element of the evaluator, enabled by 4D trajectory-based operations for optimal utilization of the prevailing airspace and air portal configuration.

1.4.1.4 Separation Assurance

In today's NAS operations, air traffic controllers provide separation assurance by visual and cognitive analysis of a traffic display and by issuing control clearances to pilots using voice communication. Decision support tools (DST) deployed in recent years provide trajectory-based advisory information to assist controllers with conflict detection and resolution, arrival metering, and other tasks. Although DSTs have reduced delays, a human controller's cognitive ability limits his/her ability to handle more than approximately 15 aircraft. Consequently, a fundamental transformation of the way separation assurance is provided is necessary in order to achieve NextGen 2025 performance objectives. Emerging aircraft performance capabilities are expected to play a key role in NextGen operations. The objective of SA research in the NextGen-Airspace Project is to identify trajectory-based technologies and human/machine operating concepts capable of safely supporting a substantial increase in capacity (e.g., 2-3X) under nominal and failure recovery operations, while accommodating airspace user preferences and favorable cost/benefit ratios. SA research in the NextGen-Airspace Project is focusing on three areas:

- **Automated separation assurance technology development.** Researchers are focusing on automatic conflict detection and resolution algorithms, trajectory analysis methods, and system architectural characteristics that together result in automated resolution trajectories that are safe, efficient, and robust under the huge variety of traffic conditions in the NAS.
- **Human/automation operating concepts research.** Researchers are addressing the need to conduct analyses of cognitive workload, situational awareness, performance under different service-provider-based and operator-based concepts of operations, as well as the roles, and responsibilities of controllers and pilots. Research includes a series of human-in-the-loop simulations of increasing complexity and fidelity.

- **System safety and failure recovery analysis research.** Researchers are addressing the need to identify component failure and recovery modes for automated SA methods, including missed conflict alerts, datalink failure, primary trajectory server failure, false read-back, human operator mistakes, and other factors.

1.4.1.5 Airspace Super-Density Operations

ASDO refers to highly efficient operations at the busiest airports and terminal airspace. Capacity at the busiest airports plays a key role in determining the efficiency and robustness of the NAS and ultimately defines the attainable growth in air traffic. Significant growth at the busiest airports as well as regional and smaller airports is needed to achieve NextGen capacity goals. The JPDO envisions a combination of new technologies enabling significant growth at large airports and increased operations at underutilized airports to absorb the expected increase. Increasing capacity in the current architecture is not scalable to meet future needs. A new operational paradigm is needed to increase terminal area capacity to meet NextGen demand. To support this goal, the NextGen-Airspace Project is conducting ASDO research in four areas:

- **Concept of operations development.** Researchers are employing rapid prototyping and fast-time simulation to assess and iteratively refine the concept of operations based on improved understanding of the fundamental challenges and development of enabling technologies to address those challenges.
- **Sequencing and deconfliction technologies development.** Researchers are advancing sequencing and deconfliction methods beyond the current practices of modified first-come-first-served scheduling and tactical separation service. Outputs of this research will be an understanding of the inherent uncertainty associated with execution of precision trajectories in ASDO airspace together with improvements in multi-objective constraint optimization for air traffic systems.
- **Precision spacing and merging technologies development.** Researchers are addressing the need to reduce the level of uncertainty inherent in aircraft operations in ASDO airspace and enable many aspects of Equivalent Visual Operations, a key capability associated with NextGen, as defined by the JPDO. Outputs of this research are procedures and technologies for airborne precision merging and spacing extended to meet multiple constraints and environmental considerations.
- **Regional ASDO resource optimization.** Researchers are working closely with the NextGen-Airportal Project to define methods for regional resource optimization to enhance regional ASDO capacity and robustness to a variety of disturbances. Outputs will include methods for managing precision and non-precision operations in the same airspace. Work will be coordinated with performance based systems research to incorporate precision performance-based concepts in ASDO airspace, such as closely spaced parallel approaches.

1.4.1.6 System-Level Design, Analysis, and Simulation Tools

SLDAST is a crosscutting technical area focused on system-level design, analysis, and simulation requirements capable of providing overarching views of the NextGen-Airspace Project's technology and concept research thrusts. Design, analysis, and simulation are closely tied, interactive activities; each is dependent on, and supportive of, the other. System design is

the process of designing a system that encompasses all of the relevant technologies and concepts emanating from the other technical areas. System analysis consists of a suite of studies that answer key questions coming from system design, guide design decisions, and influence the final design of the system. System simulation is the process of integrating, where possible, models of technologies from other technical areas into a common simulation platform or using them in combination to view multiple designs. SLDAST has three main objectives:

- Conduct system-level performance assessments to identify the collective impact of NASA's concepts and technologies. These assessments will include relevant technologies from both the NextGen-Airspace Project and NextGen-Airportal Project. The system-level performance assessments will include key concepts, not just point solutions. For example, these performance assessments will include both air-borne and ground-based separation management functions.
- Conduct interaction studies between multiple research areas. These interaction studies will include key interactions between TFM and DAC, TFM and SA, ASDO and surface work, and other elements. For example, TFM and DAC interactions will study how much capacity can be achieved through airspace boundary adjustment before the demand must be managed for demand-capacity imbalance problem.
- Develop supporting scenarios, models and their integration, assumptions, metrics, and experiment plans. Their goal is to support the interaction studies and system-level performance assessments.

1.4.2 NextGen-Airspace and NextGen-Airportal Project Interaction

Surface and terminal-area operations areas have unique constraints, but airspace and airport solutions are necessarily dependent upon one another. Developments in one area rely on close coordination with developments in the other to ensure overall capacity improvements throughout the NAS. The Airportal and Airspace Projects are working together to ensure appropriate research activities are coordinated and integrated across the two projects. Examples include:

- A joint NASA Research Announcement (NRA) solicitation for metroplex research was developed and posted during FY2007. Three proposals were awarded - two being monitored by Airportal, and one by Airspace. A Metroplex Workshop was held on September 10-11, 2008. A follow-on workshop is planned for February 2009.
- Two NASA researchers are assigned to both Airspace (ASDO) and Airportal (CADOM), helping to facilitate coordination between the two related RFAs.
- The API for Airportal and Metroplex Integration (AMI) acts as the Airportal liaison to the SLDAST RFA, supporting system analysis functions being planned and conducted within SLDAST. There is a significant integration opportunity in developing common metrics and scenarios, and coordinating the use of complementary resources.

As part of the FY2009 project realignment effort, the Project Scientists for Airportal and Airspace developed a process by which common areas of research between the two projects were identified, and for which proposed "shared" milestones were developed where appropriate. This process (and its status) was briefed to the PIs and PMs for both projects, and to the ASP office, during the 1st quarter of FY2009, and approval to proceed was received.

The process and the proposed list of shared milestones were briefed to the APIs in December, 2008. They have been tasked to collaborate to make changes (where appropriate) to the shared-milestone descriptions, metrics, dependencies, and delivery dates to fully align the work between the two projects. It is expected that final drafts of the shared milestones will be completed during the 2nd quarter of FY2009, and the projects will submit the appropriate Change Request forms to update the affected milestones.

To ensure the effective oversight and tracking of these shared milestones, the following management plan is proposed. The appropriate APIs for a shared milestone are responsible for their RFA's contribution as identified in the milestone description. They are responsible for working closely together to allocate tasks within a joint milestone, to track milestone progress, and to deliver a single integrated product toward milestone completion. Working with Research Managers, the APIs lead the shared work effort and ensure all necessary cross-RFA coordination between the researchers. The PSs for both projects will facilitate API coordination by providing technical or programmatic guidance where needed, ensuring the cross-project teams are meeting the needs of both projects, and addressing issues requiring project intervention. The PSs will conduct regular (bi-weekly to monthly) telecons with the APIs to discuss the status of current research activities related to the shared milestone(s), upcoming events, and any coordination needs, and to raise any issues that need to be resolved.

1.4.2.1 Interfacing with other Projects

The NextGen-Airspace Project Principal Investigator (PI) frequently communicates with PIs from the Integrated Intelligent Flight Deck and the Integrated Vehicle Health Management projects on cross-project and cross-program collaboration issues. Further cross-project and Program collaboration takes place in research associated with NRA subtopics—e.g., the development of off-nominal scenarios in air traffic management. The Project developed NRA subtopics in this area with input from projects in the Fundamental Aeronautics and Aviation Safety programs as well as from the NextGen-Airportal Project.

1.4.3 Milestones

Milestone documents appear in Appendix B and include the following:

- B-1. FY2007 – FY 2014 Milestones
- B-2. FY2009 – FY2014 Milestone Schedule
- B-3. FY2009 – FY2011 Key Milestones

2. PROJECT EXECUTION

2.1 Resources

Table 1 contains the NextGen-Airspace resources based on the President's FY2009 budget.

Table 1. NextGen-Airspace Resources Based on President's FY2009 Budget

Table 1. Removed from External Release version of Project Plan.

2.1.1 Full-Time Equivalent (FTE) and Work-Year Equivalent (WYE)

Text removed from External Release version of Project Plan.

2.1.2 Procurement

Text removed from External Release version of Project Plan.

2.1.3 Facilities and Laboratories

NASA facilities and laboratories will be utilized extensively in FY2009 for research in SA, ASDO, TPSU, and SLDAST.

2.1.3.1 NASA Facilities

NASA Facilities required in FY2009 are as follows:

- Crew-Vehicle Systems Research Facility (CVSRF)
 - This facility houses two simulators capable of full-mission simulation. These simulators interact with each other (as well as with other ATM labs) by means of a High Level Architecture (HLA), allowing for enormous flexibility and customization. Using CVSRF's highly sophisticated simulators and laboratory (the Boeing 747-400, the Advanced Concepts Flight Simulator, and the Air Traffic Control (ATC) Laboratory), researchers are able to study the effects of automation and advanced instrumentation on human performance.
 - Typical research in the CVSRF may be a human-in-the-loop (HITL) simulation of procedures for enabling very closely spaced parallel approaches in all weather conditions.
- Cockpit Motion Facility
 - The Cockpit Motion Facility (CMF) is made up of one motion system site and four fixed-base sites. The motion system site contains a six-degree-of-freedom state-of-the-art synergistic motion base with 76-inch extension actuators. The four fixed-base sites provide homes for the simulator cockpits when they are not resident on the motion system. The cockpits are fully operational when located in the fixed-base sites and run totally independent of each other and the motion system site. The four cockpits are the Research Flight Deck Simulator, the Integration Flight Deck Simulator, the Generic Flight Deck Simulator, and a future, undefined simulator.
 - Typical research in the CMF may be a HITL simulation addressing merging and spacing concept of operations for terminal area that utilizing airborne-based technology requirements for FAA planned merging and spacing operations.

2.1.3.2 NASA Laboratories

NASA Laboratories required in FY2009 are as follows:

- Flight Deck Display Research Laboratory (FDDRL)
 - The FDDRL conducts research and development for advanced human-centered displays and controls that support the management of 4-D flight paths. Low-,

medium- and high-fidelity simulations are used to develop guidelines and test concepts. Low-fidelity simulations include traditional part-task research studies of specific interface design features and concepts, while mid- and high-fidelity simulations are used to test more integrated interface principles and concepts.

- A primary goal of the FDDRL is to provide human-centered solutions and concepts which address projected changes in roles and responsibilities on future flight decks. Chief among these are research in real-time flight replanning which takes into account constraints, such as required times of arrival, as well as surrounding traffic, weather, and terrain.
- Airspace Operations Laboratory (AOL)
 - The AOL evaluates ATM concepts and explores human-system interaction issues in a high-fidelity human-in-the-loop simulation environment designed to allow rapid prototyping of NextGen concepts. This environment allows simulations of aircraft, ATM systems and communication infrastructure for both current day operations and a variety of future, highly automated concepts. Controller workstations are realistic emulations of today's en route, Terminal Radar Approach Control (TRACON) and oceanic systems. They also include a full suite of advanced decision support tools and automated functions for conflict detection and resolution, trajectory planning, scheduling and sequencing, and managing advanced levels of airborne equipment.
 - Experiments typically address problem of human-automation integration and allocation of roles and responsibilities required to achieve the significant capacity increases targeted for NextGen.
- Air Traffic Operations Laboratory (ATOL)
 - The ATOL is a simulation laboratory in which NASA evaluates new air traffic management concepts, maintaining appropriate levels of compatibility with real-world avionics system architectures and emerging NAS infrastructure. The simulation environment is called the Airspace and Traffic Operations Simulation (ATOS). ATOL is comprised of computer workstations used as pilot stations flown by real pilots who interact with each other in a simulated airspace environment in various configurations and air traffic scenarios with hundreds of additional automated aircraft. The lab supports 'pseudo-pilot' (multi-aircraft) control and remotely piloted and non-piloted aircraft operations. ATOS can also connect to high-fidelity flight-deck simulators as part of the traffic environment.
 - An example of the work performed in the ATOL is an experiment that will be a closed loop test with multiples of current air traffic in a generic airspace with varying types of error/uncertainty and/or uncertainty compensation (winds and trajectory) to analyze and quantify the effectiveness of a distributed approach to Separation Assurance of aircraft. Prediction error and uncertainty models will be incrementally incorporated in experiment scenarios to analyze the sensitivity of the system to the effect of the individual sources of uncertainty as well as their interactions and collective effect.

- ATC Simulation Laboratory
 - The ATC Simulation Laboratory provides generic ATC capability rather than an exact duplicate of the current system. It can operate in three modes: single-cab (with either the Advanced Concepts Flight Simulator or the B747-400 participating in the study), dual-cab (with both cabs participating), or stand-alone. The ATC Lab consists of PC-based computer workstations that can be used to create any combination of radar controller positions and “pseudo-pilot” stations.
 - An example of the work done there is a HITL simulation of controller-managed separation on RNP routes that provided varying levels of control.
- Airspace Concept Evaluation System (ACES) Laboratory
 - Airspace Concepts Evaluation System (ACES), is a NASA computer simulation of the air transportation system, this is a multi-fidelity non-real-time modeling and simulation system with full gate-to-gate representation of all the major components of the National Airspace System (NAS). NASA and others have used ACES to perform various air traffic management studies by simulating today’s traffic volume (1X) and conditions as well as future traffic volumes (2X and 3X) and conditions.
 - An example study is the wind-optimal routing study. This study analyzes the economic and safety impacts of different flight routing methods in the NAS. It compares filed flight routes, wind-optimal routes, and great-circle routes. Routing differences are measured by flight time, fuel burn, sector count, and number of conflicts.

2.2 Management

2.2.1 Organizational Structure

The NextGen-Airspace Project is managed by a management team consisting of the PI, PM, and PS. Supporting the management team is a group of research and programmatic personnel. At least one Associate Principal Investigator (API) is assigned to each RFA. The API is responsible and accountable to the PI for supporting the technical content of each API’s respective RFA. **Figure 2** illustrates the Project management structure. A detailed listing of roles and responsibilities is included in **Appendix C**.

The APIs will assist the PI and PS in the planning and execution of the Project’s research objectives. The PI and PS, with the APIs, will define technical roadmaps, including Project goals, research performance objectives, and requirements.

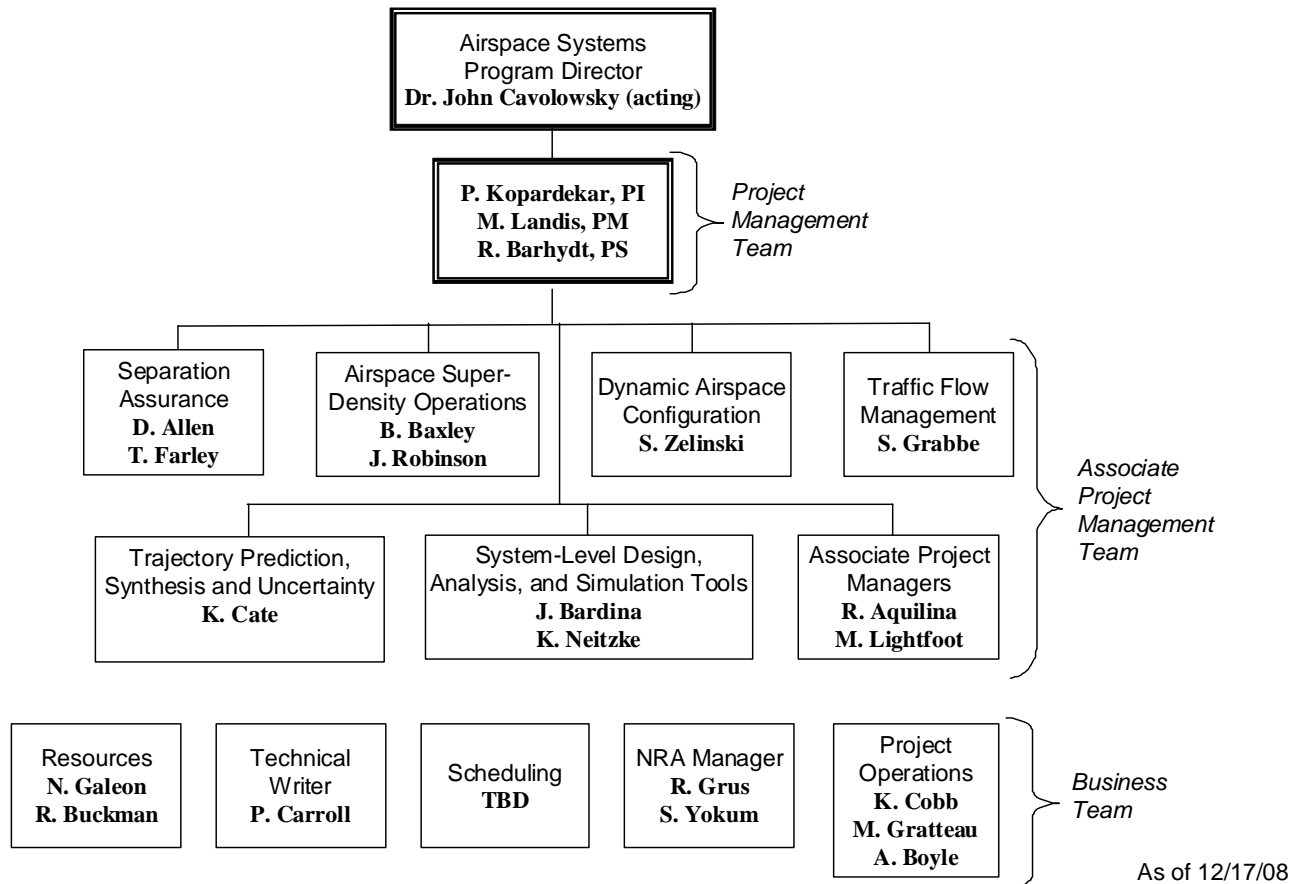


Figure 2. Project Management Structure

2.2.2 Project Reporting and Reviews

Reporting and reviews within the NextGen-Airspace Project and the Airspace Systems Program range from scheduled telephone conferences to internal and external peer technical reviews. The following section identifies reporting and review formats currently in place.

2.2.2.1 Communication and Reporting Formats

- Twice weekly telephone conferences between the PI, PM, and PS to discuss near-term issues and actions
- Weekly telephone conferences with the Program Office involving PIs, PMs, and PSs from the NextGen-Airspace and NextGen-Airportal projects to discuss near-term and strategic issues and actions
- Weekly Project status and issues meetings, including budget status, events, activities, accomplishments, and Project milestones (ARC and LaRC Center Directors)
- Periodic meetings with PIs, PMs, and PSs in both NextGen-Airspace and Next-Gen-Airportal projects to discuss common issues. NextGen-Airspace and NextGen-Airportal inter-project technical planning and integration coordination between APIs is scheduled,

at least annually and includes jointly developed, NRA subtopic discussions, gap analysis and strategy to address gaps, technical workshops, and NRA kickoff meetings.

- Program integration management biweekly telephone conference with NextGen-Airspace Project and NextGen-Airportal Project PMs, APMs, and resource analysts
- Biweekly telephone conferences with the PI, PM, PS, APIs, and APMs in the NextGen-Airspace Project to discuss current and near-term technical and programmatic issues
- NASA 90-Day Report submitted on the third Monday of each month to the Program Office. The 90-day Report is a compilation of events, activities, and significant Program and Project milestones planned for the next 90 days. The report is integrated at the Agency level.
- Annual Technical Interchange Meeting focusing on foundational and multi-disciplinary work. Participation includes university and industry PIs involved in NRA and SAA research activities supporting the project. Participation by other university, industry, and other government agencies requires written invitation.

2.2.2.2 Review Formats

- Quarterly technical status and programmatic review of the Project provided by the PI and PM to the Program Director. This review is the primary source of information used by the Director in the Program's quarterly briefing and review with the ARMD Associate Administrator.
- Annual internal and external technical peer reviews, with schedule and content determined by the Program and ARMD.

2.3 Controls and Change Process

The FY2009 Project Plan is an agreement between the PI, PM, Center POCs, and the Program Director. The plan documents the technical plan, milestones/deliverables, schedules, resources management approach, etc., to ensure successful delivery of technical products to the Airspace Systems Program. Programmatically, milestone completion constitutes the delivery of technical products to the PI or Program Director from the API.

2.3.1 Documenting Milestone Completion

Level 1 through Level 4 milestone completion will be documented in writing by the API using the NextGen-Airspace Milestone Completion Form. The form will be submitted by the API and APM to the PI for acceptance.

Documentation of all Key Milestone completions will be documented in writing by the API using the NextGen-Airspace Milestone Completion Form. The form will be submitted by the API and the APM to the PI for acceptance. The PI will forward the form to the Program Director for concurrence.

Once approved, the Milestone Completion Form will be submitted to the Project Manager. The original form and supporting documentation will be filed. An electronic copy will be stored on NX and the Scheduler will be notified that the milestone has been completed.

2.3.2 Documenting Milestone Change

Change to Level 1 through Level 4 milestones will be documented in writing by the API using the NextGen-Airspace Milestone Change Form. The form will be submitted by the API and APM for acceptance by the PI for one or more of the following elements of a milestone:

- Title or description.
- Scheduled completion date slip more than one quarter within the fiscal year or any slip into the next fiscal year. (The API/APM will consult with the scheduler to determine if successor milestones will be impacted).
- Metric.
- Exit criteria.
- Other (as determined by the API and APM).

Change to Key Milestones will be documented in writing by the API using the NextGen-Airspace Milestone Change Form. The form will be submitted by the API and APM to the PI for acceptance. The PI will forward the form to the Program Director for concurrence.

Once approved, the Milestone Change Form will be submitted to the Project Manager. A Milestone Change Request Number will be added to the form. The original form will be filed. Copies of the approved form will be provided to the API and Scheduler. An electronic copy will be stored on NX.

2.4 Risk Management

Risk management is a continuous process that requires a risk manager to identify risk items, analyze their impact on Project milestones, prioritize risk items, develop and carry out a plan for risk mitigation or acceptance, track risk and mitigation plan, support timely decisions to control risk, and ensure that risk information is communicated and documented. The NextGen-Airspace Project documented a risk management process in the *NGATS ATM-Airspace Project Risk Management Plan*, which was signed by the PI and PM in FY2007. In FY2008, the name of the plan changed to the *NextGen-Airspace Project Risk Management Plan*. The Project does not include hardware used for flight (piloted or unpiloted), flight control software, wind tunnel testing, or systems that could result in potential harm to personnel or property and, as such, is not required to develop a Safety and Mission Assurance Plan, per Section 5.2.3.9 of NPR 7120.8.

Table 2 identifies FY2008 open risk items carried into FY2009.

Table 2. FY2008 Open Risk Items

Risk No.	Risk Title	Risk Status	Mitigation Actions
9	Insufficient lab staff	Open	Release of RFP early FY2009.
16	Research integration between centers	Open	Watch status. Project goals for work across Centers set and identified as a project priority.
19	Risk analysis on Merging and Spacing Task Plan SLDAST003	Open	Negotiation between Project and Center Management in progress. Redeployment of FTE resources or WYE under consideration.
20	Cross-Project support for task plan SLDAST.0808	Open	Watch status. Scheduled biweekly with SLDAST API and Project Scientists for Airspace and Airportal.
25	Coordinated Strategic Plan needed in ASDO	Open	Airportal coordination in process. Workshop in CADOM and Metroplex.
26	Creating and Implementing the right SLDAST product	Open	Watch status - SLDAST Milestone planning coordinated with Research managers, APIs and PS for common understand and buy in.
27	ATOL staffing issues	Open	LaRC FTE hiring of 2 FTE to support ATOL authorized.
33	Paper for airborne-based separation procedures & standards coordinate w/ICAO review	Open	Paper given high priority- progress monitored by API/research manager.
34	EFB (electronic flight bag) integration into Integrated Flight Deck	Open	EFB was finally installed and operating, but not in time for the HITL experiment of M&S Phase II. Will use the ACSS EFB during next experiment.
36	Succession plan in SA expertise	Open	Watch status. Address as part of realignment process.
37	Overall FTE support	Open	Watch status. Re-evaluate during realignment process.

2.5 Acquisition Strategy

Approximately 65% of the NextGen-Airspace Project's FY2009 budget funds NASA Research Announcement (NRA) and competitively awarded performance-based contracts. The Project's acquisition strategy for addressing the ATM research and development needs of NextGen, as defined by the JPDO, includes the following:

- The ARMD NRA is used to solicit proposals for research in areas where NASA needs to enhance its core capabilities.
- Existing performance-based, in-house contracts are used to support research activities for facility and simulator operations, software integration and development, and project management tasks.
- Non-Reimbursable Space Act Agreements (SAAs) are pursued to collaborate with industry and other U.S. government agencies.
- The Project has established close working relationships with the acquisition organizations at NASA ARC and LaRC. At ARC a contracting officer is co-located with the NextGen-Airspace Project staff. In addition, the project has assigned one full time equivalent (FTE) to serve as a full-time NRA manager/Contracting Officer Technical Representative (COTR) to assist the project management team in the NRA and other acquisition activities. **Table 3** lists all NRAs awarded to-date.

Table 3. Awarded NRA Tasks

Round 1 FY06 -07			
TFM	University of Maryland, College Park	Ball	Dynamic, Stochastic Models for Managing Air Traffic Flows
TFM	Georgia Tech Research Corp.	Clarke	Approaches to TFM in the Presence of Uncertainty
TFM	Washington State University	Roy	Control-theoretic Design and Numerical Evaluation of Traffic Flow Management Strategies under Uncertainty
TFM	University of California, Berkeley	Bayen	A Unified Approach to Strategic Models and Performance Evaluation for Traffic Flow Management
TFM	Massachusetts Institute of Technology	Hansman	Cognitively Based Traffic Complexity Metrics for Future NGATS Concepts of Operations
TPSU	L-3 Communications Titan Corp.	Vivona	Development of Algorithms and Techniques for Trajectory Prediction Accuracy and Uncertainty Estimation
TPSU	L-3 Communications Titan Corp.	Idris	Trajectory Flexibility Preservation and Constraint Minimization for Distributed ATM with Self-Limiting Traffic Complexity
SA	Purdue University	Landry	Analysis and development of strategic and tactical separation assurance algorithms
SA	University of California, Santa Cruz	Erzberger	Concepts and Algorithms for Automated Separation Assurance
SA	Stanford University	Tomlin	Integrating Collision Avoidance and Tactical Air Traffic Control Tools
SA	California State University, Long Beach	Strybel	Metrics for Operator Situation Awareness, Workload, and Performance in Automated Separation Assurance Systems
ASDO	Metron Aviation	Krozel	Mitigation of Weather Impacts in Dense Terminal Airspace
ASDO	Massachusetts Institute of Technology	Hansman	Optimization of Super-Density Multi-Airport Terminal Area Systems in the Presence of Uncertainty
SLDAST	San Jose State University	Freund	Computational Models of Human Workload: Definition, Refinement, Integration, and Validation in Fast-time National Airspace Simulations
SLDAST	George Mason University	Sherry	Analysis of NGATS Sensitivity to Gaming
Round 2 FY07			
PBS	CSSI, Inc.	Mondoloni	A Method for System Performance Evaluation from Air/Ground Application Performance Under Various Operational Concepts
PBS	Georgia Institute of Technology	Volovoi*	A Conceptual and Computational Framework for Identifying and Predicting the Performance of Novel Airspace Concepts of Operation
PBS	Intelligent Automation, Inc.	Manikonda	Multi-Fidelity CNS Models to Support NGATS Concepts
TFM	Optimal Synthesis, Inc.	Menon	Multi-Resolution Queuing Models for Analyzing the Impact of Trajectory Uncertainty and Precision on NGATS Flow Efficiency
TFM	University of California, Berkeley	Hansen	Advanced Stochastic Network Queuing Models of the Impact of 4D Trajectory Precision on Aviation System Performance
TFM	Mosaic ATM, Inc.	Cook	Modeling Non-Convective Weather Impacts on En Route Traffic Flow Management

TFM	Metron Aviation	Krozel	Translation of Weather Information to Traffic Flow Management Impacts
TFM	L-3 Communications Corp.	Idris	Feasibility and Benefit Assessment of a Concept of Operations for Collaborative Traffic Flow Management
TPSU	L-3 Communications Corp.	Vivona	Analysis and Comparison of Capabilities and Requirements for Aircraft Trajectory Prediction Technologies
TPSU	University of Minnesota	Zhao	A Unified Approach to the Documentation, Analysis, and Cross-Comparison of Trajectory Predictors
DAC	Mosaic ATM, Inc.	Brinton	Assessment of Concepts and Algorithms for Dynamic Airspace Allocation
DAC	Metron Aviation, Inc.	Hoffman	Overall Airspace Organization and Dynamic Airspace Allocation Schemes
DAC	CSSI, Inc.	Rodgers	The Development of Concepts of Operation and Algorithms to support Dynamic Airspace Allocation as a Function of Equipage, Traffic Density and Weather
ASDO (METRO)	Mosaic ATM, Inc.	Atkins	Investigating the Nature of and Methods for Managing Metroplex Operations
Round 3 FY08			
ASDO	Purdue University	Landry	Transition to Super Density Operations Capability – 2015 Timeframe
ASDO	San Jose State University	Gore	Identification of NextGen Air Traffic Control and Pilot Performance Parameters for Human Performance Model Development in the Transitional Airspace
PBS	Raytheon Intelligence and Information Systems	Finkelsztein	Weather Scenarios Generator and Server for the Airspace and Traffic Operations Simulation
PBS	Sensis Seagull Technology Center	Peters	Integration of Weather Data into Airspace and Traffic Operations Simulation (ATOS) for Trajectory Based Operations Research
PBS	Raytheon Intelligence and Information Systems	Finkelsztein	A Four Dimensional Dynamic Required Navigation Performance Construct to Support NextGen Concepts
SA	Logistics Management Institute	Hemm	Safety Analysis of Today's Separation Assurance Function
SLDAST	The University of Virginia	Patek	Multi-scale Tools for Airspace Modeling and Design
SLDAST	San Jose State University	Lee	Identification, Characterization, and Prioritization of Human Performance Issues and Research in the Transition to Next Generation Air Transportation System (NEXTGEN)
SLDAST	Sensis Seagull Technology Center	Hunter	Linking Airspace Modeling and Simulation Tools of Variable Fidelity and System Scope
SLDAST	Optimal Synthesis, Inc.	Menon	Open-Source based Software Systems for Linking Disparate Software Components
Round 4 FY08			
TFM	George Mason University	Hoffman	Marketing-based and Auction-based Models and Algorithms for En-route Airspace Allocation and Configuration

2.6 Partnerships and Agreements

The NextGen-Airspace Project is dependent upon industry, universities, and other government agencies to partner with NASA in NextGen ATM research. Early involvement of industry, other U.S. government agencies, and universities combined with frequent input, is necessary throughout the development and validation of NextGen concepts and research.

The development of system-level capabilities and integrated systems is a Level 4 effort that is appropriate for collaboration with industry partners and other government agencies. The Project will consider the following when assessing potential NASA/industry collaborations:

- Collaborations are established only when there is significant benefit to NASA and its constituencies (aerospace community, aerospace industry, academia, and ultimately the taxpayer).
- Once the collaboration is established, the results can be appropriately disseminated and validated through a peer-review process.

Additional guidelines to be considered include:

- Is the collaboration suitable for NASA to pursue?
- Does the collaboration create a significant benefit to NASA, the aerospace community, and the U.S. taxpayer?
- Does the collaboration help advance and disseminate knowledge and technology?
- Who has the dissemination and publication rights?
- Is the result of the collaboration in a form that can be peer-reviewed?
- Have we ensured that restrictions for data distribution do not prevent the advancement of knowledge in the specific discipline?

Table 4 identifies the formal agreements currently in place with industry and other US government agencies. **Table 5** lists formal agreements with other US government agencies and industry. The Project Office maintains copies of the agreements.

Table 4. Formal Agreements

Type	Title	Partner(s)	Duration	RFA Supported
MOU	A Partnership to Achieve Goals in Aviation and Space Transportation	Department of Transportation, Federal Aviation Administration (FAA)	Indefinite	Project-wide
MOA	Support of FAA R&D Field Offices at NASA Research Centers	FAA	December 2007	Project-wide
MOA	JView Visualization Support for the Next Generation Air Transportation System (NextGen)	Air Force Research Laboratory, Information Directorate (AFRL/IF)	July 2010	SLDAST
Non-reimb. SAA	For Definition of Trajectory Requirements and ATM Architecture Design	Lockheed Martin Transportation and Security Solutions	January 2007	SA ASDO SLDAST
Non-reimb. SAA	Collaborative research in the area of ADS-B	Aviation Communication and Surveillance Systems	March 2008	SA ASDO
Non-reimb. SAA	Arrival Management; 3D-PAM	Boeing Company	January 2008	SA ASDO
Non-reimb. SAA	In-flight advanced flight deck display usability study	InformArt, Inc.	June 2008	SA ASDO

Table 5. Formal Agreements with Other US Government Agencies and Industry

Agency	Title/Focus	Responsible Center	IA Established
FAA	Four-Dimensional Flight Management to Support the NextGen System	Langley	Sept. 2007
National Oceanic and Atmospheric Administration/National Weather Service	Support of Research to Correlate Weather and NAS Performance For NASA's Airspace System Program	Ames	Oct. 2007
FAA	Support for FAA R&D Field Offices at Ames and Langley Research Centers	Ames/Langley	April 2008
FAA/NASA/UPS	Aircraft Trajectory Data Feed To Support En Route Metering Concept Validation	Ames	Sept. 2008
United States Air Force	Support NASA air traffic automation activities by providing data analysis, integrating various weather products with ATM tools	Ames	Sept. 2008
FAA	Establish roles and responsibilities for NASA and FAA in a collaborative effort to develop the NextGen system. (Establishes coordination for Research Transition Teams)	Ames	Oct. 2008

2.7 Foreign Collaboration

The Airspace Systems Program and its legacy projects actively established participation with foreign organizations to conduct joint ATM research. The NextGen-Airspace Project is

committed to maintaining these efforts, where appropriate, and to identifying new areas of opportunity for foreign collaboration. Existing and new foreign collaborations will be aligned with the six Project RFAs.

To facilitate foreign research collaboration, the NextGen-Airspace Project established and documented guidelines for capturing and documenting foreign collaborative research efforts. The guidance is in full compliance with the U.S. Department of State's International Traffic in Arms Regulations (ITAR) policy and amendments related to project research (e.g., trajectory prediction, algorithms, etc.). Titled, *NextGen-Airspace Project Guidance on Foreign Collaboration*, the guidance document is tailored to NextGen ATM research and will serve as a template for current and future collaborative research. Rather than inhibit or discourage foreign research collaboration, the guidance is intended to facilitate and encourage collaboration where it can be demonstrated that the collaboration will add value to Project, Program, and ARMD mission, goals, and/or objectives.

The API in the respective RFA is empowered with, and responsible for, identifying new opportunities for foreign collaboration and for managing existing and new foreign research collaboration. A formal review and approval process has been developed for use in evaluating foreign collaboration proposals for consistency with Project, Program, and ARMD mission, goals, and/or objectives. Questions that must be adequately addressed by the API include, but are not limited to, the following:

- Is there a formal charter for the proposed research that delineates tasks, responsibilities, and time period?
- What vehicle will be utilized for the formal agreement (e.g., Action Plan, Letter of Authorization, Memorandum of Authorization, etc.)?
- What are the respective responsibilities between NASA and the relevant foreign organization(s)?
- Which organization(s) are responsible for assigning and managing research tasks?
- What amount of effort is required to fulfill the duties (e.g., preparation, travel, meetings, etc.)?
- Will the conduct of the foreign research impact the completion of any NextGen Project milestones?
- Is the research directly related to any Project milestones? If so, which milestone(s) are related?
- Does the research provide an advantage to foreign companies at the expense of the U.S. taxpayers? If the answer is no, why not?
- How will the performing organization(s) accommodate new requests for additional or follow-up research?
- Who will approve additional or follow-up research?

The API shall address these questions in a letter of interest and submit it to the PI for formal approval of the proposed foreign collaboration.

The API should allow 30 days for Project Office and Program review and approval or rejection. Once an agreement is at least in place, the API will be responsible for managing foreign collaboration research.

2.8 Knowledge Dissemination

NASA has a unique charter in the Space Act of 1958 to “provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.”⁶ At the Directorate level, ARMD is responsible for achieving NASA Strategic Goal 3E, to “Advance knowledge in the fundamental disciplines of aeronautics”⁷ In keeping with these aims, the NextGen-Airspace Project is committed to the widest possible dissemination of research activities and results, to the greatest extent practicable, in as timely a manner as possible. Each year the Project publishes scores of technical reports, research papers, peer-reviewed journal articles, and invited papers to disseminate the results of its research. In FY2008, the Project published more than 103 research papers and technical reports, as shown in **Table 6**. In addition to publishing and reporting research in government, academia, and industry technical forums, the Project is establishing a public website where it will make research papers and reports available to the public.

The project management team is also committed to the publication of lessons-learned concerning the planning, implementation, and execution of the Project. All lessons learned are fully and openly shared with existing projects, programs, and the appropriate organizations within the Agency. When appropriate, the Project also shares documented lessons learned with the Systems Management Office at NASA ARC and NASA LaRC and/or the NASA Office of the Chief Engineer.

⁶ Communicating NASA’s Knowledge, A Report of the Communicate Knowledge Team, NP-1998-08-24O-HQ, August 1998, page 5.

⁷ NASA AERONAUTICS RESEARCH MISSION DIRECTORATE, RESEARCH OPPORTUNITIES IN AERONAUTICS – 2008 (ROA-2008) NASA RESEARCH ANNOUNCEMENT (NRA): NNH08ZEA001N SOLICITING BASIC AND APPLIED RESEARCH PROPOSALS, March 7, 2008, page 1.

Table 6. Knowledge Dissemination

Conferences / Publications	DAC	TFM	SA	ASDO	TPSU	PBS	SLDAST	Total
Joint AIAA Aviation, Technology, Integration & Operations (ATIO) / Congress of the International Council of the Aeronautical Societies (ICAS)	6	5	7	8	1	1	3	31
AIAA Guidance, Navigation & Control (GNC)	9	8	1	2	4		3	27
AIAA Modeling & Simulation Technologies (MS&T)		1					3	4
AIAA Aerospace Sciences Meeting & Exhibit				2				2
AIAA Journal of Aircraft			2	1				3
AIAA Journal of Guidance, Control, and Dynamics		2						2
Air Traffic Control Quarterly	1	3		1				5
American Control Conference								0
Association for the Advancement of Artificial Intelligence (AAAI) Symposium								0
Conference on Radar Meteorology, American Meteorology Society								0
Digital Avionics Systems Conference (DASC)	2	1		1	1			5
Encyclopedia of Complexity and System Science		2						2
Genetic and Evolutionary Computation Conference								0
Grace Hopper Celebrating Women In Computing							1	1
HCI International Conference								0
IEEE Conference on Decision and Control								0
IEEE Proceedings Journal		2						2
iFLY Technical Progress Meetings			3					3
Institute for Operations Research and Management Sciences (INFORMS)	1	5	1					7
Integrated Communications, Navigation, and Surveillance (ICNS) Conference								0
International Federation of Automatic Control (IFAC)		2						2
International Joint Conference on Autonomous Agents and Multi-Agent Systems								0
Journal of Guidance, Control, and Dynamics	1							1
Networks and Heterogeneous Media		1						1
NextGen Human Factors Conference	1							1
SAE Aerospace Control & Guidance Systems Committee Meeting								0
SAE AeroTech Conference and Exhibition								0
USA/Europe Air Traffic Management R&D Seminar								0
Workshop on Logic, Language, Information and Computation								0
World Conference on Transportation Research								0
NASA Technical Memorandum/Report (TM/TR)		1		1				2
NASA Contractor Report (CR)					2			2
Roll-Up By RFA	21	33	14	16	8	1	10	103

3. MILESTONE RECORDS

In FY2009, the NextGen-Airspace Project will transition from the development and use of task plans documenting current year work to Milestone Records that provide descriptions and other details for each milestone. The increased focus on milestone documentation is due primarily to the following:

- The JPDO tracks Project milestones against research and development needs in the JPDO's *Next Generation Air Transportation System Integrated Work Plan*.
- The NASA Office of Inspector General has questioned the extent to which Project milestones support JPDO research and development needs.
- ARMD, the Airspace Systems Program, and the Program Assessment and Evaluation Office focus their interest and review at the milestone level, as opposed to task plans.

Milestone Records provide an annual update with focus on the near-term fiscal year. Development and updating of the Milestone Record is the responsibility of the API, with support from the APM. Working with the research manager, the API and APM develop the Milestone Records for their respective RFAs. The Milestone Record describes the work to be conducted in the current fiscal year, identifies requirements for simulation facilities and laboratories, and provides Project milestone alignment with JPDO research and development needs. Milestone Records for each RFA appear in Appendix A.

4. APPENDICES

Appendix A. FY2009 Milestone Record Activity

Appendix B. Milestone List and Schedule, Including Key Milestones

Appendix C. NextGen-Airspace Project Roles and Responsibilities

Appendix D. Acronyms and Abbreviations

Appendix E. Waivers and Deviation Log

Appendix F. Change Log

APPENDIX A. FY2009 MILESTONE RECORD ACTIVITY

Text removed from External Release version of Project Plan.

A-1. Trajectory Prediction Synthesis and Uncertainty

A-2. Dynamic Airspace Configuration

A-3. Traffic Flow Management

A-4. Separation Assurance

A-5. Airspace Super-Density Operations

A-6. System-Level Design, Analysis, and Simulation Tools

APPENDIX B. MILESTONE LIST AND SCHEDULE, INCLUDING KEY MILESTONES

Appendix B contains the following milestone documents:

- B-1. FY2007 – FY 2014 Milestones
- B-2. FY2009 – FY2014 Milestone Schedule
- B-3. FY2009 – FY2011 Key Milestones

B-1. FY2007 – FY 2014 Milestones

Appendix B-1 a list of milestones for FY2007 – FY2014.

Table 7. FY2007 – FY 2014 Milestones

Project	Level	Area	Description
AS		.1	Trajectory Prediction Synthesis and Uncertainty
	.4	.2	Performance-Based Services
	.3	.3	Dynamic Airspace Configuration
	.2	.4	Traffic Flow Management
	.1	.5	Separation Assurance
		.6	Airspace Super-Density Operations
		.7	System-Level Design, Analysis and Simulation Tools

Milestone Status Definitions	
Milestone was originally part of Project Proposal	Original
Milestone created and approved during FY09 Realignment process	Realignment
Milestone has been completed and a completion record has been signed	Completed
Milestone cancellation has been approved and is on file	Cancelled
Milestone has been merged with other milestone approval on file	Merged

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.4.1.01		Real-time data exchange for interoperability	FY11Q4	Improved trajectory Prediction accuracy relative to data shared and behavior models and increased consistency between trajectory predictions.	Demonstration of real-time data exchange between airborne and ground based systems using common language for data exchange. Deliverables include software in support of the demonstration and raw data.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.4.3.01	Critical	Dynamic airspace configuration concepts experimentally validated		Frequency of airspace reconfiguration, extent of airspace reconfiguration, system stability measures, amendments and restrictions imposed on users, airspace complexity distribution.		Original	Cancelled
AS.4.3.02		Airspace class integration	FY14Q4	% delay recovered over current sector design, corridor utilization.	Publication, white paper or report.	Realignment	
AS.4.4.01	Critical	Develop and test early integrated TFM concepts for advanced Traffic Flow Management to accommodate user preferences, reduce delays and increase efficiency under all-weather conditions	FY11	The specific metrics for this milestone include delays, throughput, fuel efficiency, flight duration, complexity distribution, workload, and user preference accommodation. The actual savings will be dependent on the concept of operations.	Conference or journal publication describing key algorithms and models associated with the early integrated TFM and the results of fast-time simulation experiments.	Original	
AS.4.5.01	Critical PART	Auto SA simulation: homogeneous airspace under off-nominal conditions	FY13Q2	SA performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data.	Technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.4.5.02		Auto SA simulation: Mixed operations airspace under off-nominal conditions	FY14Q2	SA performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data.	Technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	
AS.4.5.03		Final report on functional allocation	FY14Q4	None	Technical manuscript written and accepted for publication.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.4.6.01		ASDO final concept of operations for automated, mixed operations in metroplex environment	FY14Q3	<ul style="list-style-type: none"> - For major airports, increase peak aircraft throughput by 15%, decrease mean delay by 25% and decrease mean flight time during descent by 2 minutes. - For metroplex, increase peak operations by 100%, decrease mean flight time during descent by 3 minutes and ensure full utilization of available runway resources. 	Technical Publication documenting refined concept of operations. Conference publication minimum, journal publication preferred.	Original	
AS.4.7.01	Critical	Develop refined system-level concept of operations based on results of modeling, safety, cost-benefits, and human-in-the-loop simulations		A refined concept of operations will be delivered.		Original	Cancelled
AS.4.7.02		System-level assessment III	FY14Q4	System-level capacity, robustness, and system level performance indicators.	Published paper on assessment results, integrated concept option descriptions.	Realignment	
AS.3.1.01	Critical	Develop, validate, and document Common Trajectory Model algorithms and capabilities for NGATS applications within En-Route and transition airspace.	FY08	Trajectory accuracy, predictability.	Experiment plan for interoperability.	Original	Cancelled Merged

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.1.02		Identification of data for interoperability	FY09Q4	Increased trajectory consistency relative to data shared and behavior models, number of new functions to support interoperability. # of TPs analyzed.	Systems analysis of critical data to be exchanged between disparate systems (conference/journal paper).	Original	
AS.3.1.03	Critical	Comprehensive assessment of intent errors	FY10Q4	Trajectory prediction errors, as a function of measured (or inferred) intent errors for relevant conditions that are key to NextGen automation applications.	Conference/journal publication documenting categorizations of relevant intent errors in terms of the relative impact (on TP accuracy), source and frequency of occurrence.	Original	
AS.3.1.04	Critical	Trajectory algorithms for super density airspace	FY11Q4	Trajectory prediction accuracy, reliability.	Terminal area sensitivity studies (paper). Software deliverable of the GenAlt logic for terminal. Paper on validation of algorithms for terminal/super density operations.	Original	
AS.3.1.05		Application of formal method of validation	FY10Q3	Fidelity of scenario, # of TPs analyzed.	Conference/journal publication documenting quantitative analysis and metrics using available data.	Realignment	
AS.3.1.06		Implement data exchange language	FY10Q4	Trajectory Prediction accuracy relative to data shared and behavior models.	Experiment with disparate trajectory predictors exercising common data exchange language to analyze accuracy improvements. Deliverables include software in support of the demonstration and raw data.	Realignment	
AS.3.1.07		Common trajectory modeling	FY12Q4	Trajectory prediction accuracy in 4 dimensions.	Library of trajectory prediction functions capable of being used by multiple systems.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.1.08		Advance TP performance modeling	FY13Q4	Trajectory accuracy, predictability.	Check-in of new aircraft performance models.	Realignment	
AS.3.2.01		Produce a list of candidate NGATS operational concepts	FY07	NGATS vision mapping gaps.		Original	Completed
AS.3.2.02	Critical	Produce a detailed hierarchical structure of RTSP elements and advanced performance measures needed to support candidate NGATS operational concepts	FY08	Organization of performance attributes to map with level of service.		Original	
AS.3.2.03		Working with industry and JPDO's Shared Situation Awareness IPT, define the parameters associated with RCP and RSP		Definitions of RCP, RSP, RNP.		Original	Cancelled Merged
AS.3.2.04	Critical	Parametric RTSP batch studies of AAC and 4D-ASAS concepts are completed under nominal and failure mode conditions		Capacity, throughput, efficiency, safety, predictability.		Original	Cancelled Merged
AS.3.2.05		Human-in-the-loop studies of AAC and 4D-ASAS concepts are completed using minimum RTSP levels determined by previously performed batch studies.		Capacity, throughput, efficiency, safety, predictability.		Original	Cancelled Merged
AS.3.3.01		Categorize events that trigger airspace reconfiguration	FY08	Number of scenarios documented, number of events cataloged.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.3.02		Develop an operational framework for dynamic airspace configuration	FY08	Breadth and depth of taxonomy of the “building blocks” for airspace configuration and the “degrees of freedom” available to dynamically modify them.		Original	Completed
AS.3.3.03	Critical	Identify complexity metrics for higher levels of automation and higher traffic densities	FY08	Binary: milestone completion status.		Original	Completed
AS.3.3.04	Critical	Airspace flexibility	FY09Q4	Workload measures per amount and frequency of airspace change. Degree of airspace change.	Publication, white paper or report.	Original	
AS.3.3.05		Generic airspace	FY10Q4	Time to learn sector-specific knowledge, amount of sector-specific knowledge eliminated, effectiveness of methods.	Publication, white paper or report.	Realignment	
AS.3.3.06		Validate flow corridors feasibility	FY11Q4	Workload measures for each procedure.	Publication, white paper or report.	Realignment	
AS.3.3.07		Interactions between airspace classes	FY11Q4	Number of algorithms, procedures developed.	Publication, white paper or report.	Realignment	
AS.3.3.08		Dynamic terminal airspace II	FY12Q4	Number of integration methods developed, capacity, efficiency, and robustness.	Publication, white paper or report.	Realignment	
AS.3.3.09		Refine DAC concepts	FY13Q4	% delay recovered over current sector design	Publication, white paper or report.	Realignment	
AS.3.3.10		Refine flow corridor procedures	FY13Q4	% delay recovered over current sector design, corridor utilization.	Publication, white paper or report.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.4.01	Critical	Develop Traffic Flow Management concepts at the regional and national levels for different planning intervals to increase efficiency, reduce delays, and accommodate user preferences	FY08	The output of this effort is an integrated set of advanced TFM concepts and the associated algorithms/models that will be integral to the development of the early integrated TFM.		Original	Completed
AS.3.4.02		Early integrated TFM concept definition and development, including initial concept of operation focused on national and regional TFM for increasing flow management efficiency and accommodating user preferences	FY09Q4	The output of this effort will be a baseline integrated TFM concept of operations that describes the composition and architecture of TFM functions as well as their temporal and geographic scope.	Conference or white paper describing the early integrated TFM concept definition.	Original	
AS.3.4.03		Determine user and service provider roles to accommodate user preferences and increase efficiency	FY10	The product of the milestone will identify the type of decisions that users and service providers should make to promote maximum efficiency, balance workload, and accommodate user preferences. The milestone report will also describe the information needs and exchanges to enable CDM to handle 3x capacity.	Conference or journal publication describing methods or concepts for incorporating user preferences into the traffic flow management decision making process.	Original	

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AS.3.4.04	APG	Expand Traffic Flow Management concepts to address weather modeling uncertainty to promote higher predictability and efficiency	FY10	The outputs of this activity are probabilistic models/algorithms, and weather product requirements, for improved predictions of NAS resource demand/supply under uncertainty.	a. A conference and/or white paper with a CD or DVD containing the actual and predicted sector capacities, and the corresponding traffic/weather scenarios. b. A conference and/or white paper with a CD or DVD containing the actual and predicted peak traffic demand data in fifteen-minute intervals over a 2-hour planning horizon, and the corresponding traffic/weather scenarios.	Original	
AS.3.4.05	Critical	Assess representative system-wide TFM models	FY10	The output of this effort is a suite of advanced TFM tools integrated into a simulation test bed.	Conference or journal publication describing the results of the system-wide traffic flow management experiments conducted in support of this milestone.	Original	
AS.3.4.06		Simulation assessment of advanced TFM concepts.		The output of this effort will be a system-level simulation assessment of the feasibility and benefits of implementing advanced TFM techniques.		Original	Cancelled

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.4.07		Initial collaborative experiments	FY12Q4	Demonstrate a 5% improvement in the ability to accommodate user preferences with the algorithms and models developed in support of this milestone over more traditional traffic flow management approaches that neglect to account for user preferences.	Conference or journal publication describing the results of the initial collaborative traffic flow management experiments.	Realignment	
AS.3.4.08		Refined collaborative experiments	FY14Q4	Demonstrate a 10% improvement in the ability to accommodate user preferences with the algorithms and models developed in support of this milestone over more traditional traffic flow management approaches that neglect to account for user preferences.	Conference or journal publication describing the results of the refined collaborative traffic flow management experiments.	Realignment	
AS.3.4.09		Baseline flow planning under uncertainty	FY12Q4	Demonstrate a 5% reduction in total delays when managing flights in the presence of system uncertainties over current TFM practices that rely on an uncoordinated collection of open-loop deterministic controls, such as ground delay programs, miles-in-trail restrictions, and playbook reroutes.	Conference or journal publication describing the enhancements to the baseline early integrated TFM and the results of the fast-time simulations conducted in support of this milestone.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.4.10		Refined flow planning under uncertainty	FY13Q3	Demonstrate an 8% reduction in total delays or a 5% improvement in the ability to accommodate user preferences when managing flights in the presence of system uncertainties over current TFM practices that rely on an uncoordinated collection of open-loop deterministic controls, such as ground delay programs, miles-in-trail restrictions, and playbook reroutes.	Conference or journal publication describing the agile, iterative approaches to managing traffic flows.	Realignment	
AS.3.4.11		Agile decision making with uncertainty	FY14Q4	Demonstrate a 10% reduction in total delays or an 8% improvement in the ability to accommodate user preferences when managing flights in the presence of system uncertainties over current TFM practices that rely on an uncoordinated collection of open-loop deterministic controls, such as ground delay programs, miles-in-trail restrictions, and playbook reroutes.	Conference or journal publication describing the key models, algorithms, and concepts that comprise the integrated, agile decision making system.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.5.01	APG	Flight test evaluation of an airborne situation awareness based application.	FY07	Metrics that will be obtained in these flight trials include fuel savings compared to normal operations, system effectiveness in a flight environment, and operational acceptance.		Original	Completed
AS.3.5.02		Field evaluation of trajectory analysis technology with aircraft CNS technology for time-based metering	FY07	Trajectory accuracy, fuel savings, noise footprint, workload, emissions.		Original	Completed
AS.3.5.03	Critical APG	Trajectory analysis technology for automated separation assurance	FY08	Trajectory efficiency comparable to or better than today's operations. Near zero losses of separation. Integrated and coordinated functionality for strategic and tactical resolutions. Integrated trajectory analysis for aircraft with mix of equipage. Trajectory analysis for limited failure modes. Results based on laboratory analysis of actual Center traffic data in en route and transition airspace. Metrics analyzed as a function of traffic density and complexity.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.5.04	PART APG	Service-provider-based automated separation assurance simulation	FY08	Objective experimental data to quantify human workload, safety, and trajectory efficiency as a function of human/machine operating concept during nominal and failure modes in en route & transition airspace. General consistency with laboratory derived metrics (e.g., AS.3.5.03) and understanding of inconsistencies. Subject matter expert feedback (FAA, airlines, controllers, pilots) on operating concepts.		Original	Completed
AS.3.5.05	PART IBPD APG	Auto SA performance: time-based constraints	FY09Q3	SA performance measures for efficiency and safety.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.3.5.06	PART IBPD APG	Auto SA HITL: 4D with common definitions	FY10Q4	SA performance measures for efficiency, safety & capacity; human workload measures; subjective data.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.3.5.07	Critical IBPD PART	Integrated SA capabilities: 4D with dynamic weather & complexity constraints	FY11Q2	SA performance measures for efficiency and safety.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.5.08	PART	Safety assurance via light-weight formal methods and simulation		Methods and scenarios developed and tested with SA technology and operating concepts that probe the possible safety envelope. System safety defined under wide range of scenarios and conditions.		Original	Cancelled Merged
AS.3.5.09		3D-PAM/EDA evaluations	FY11Q2	SA performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data.	Technical manuscript written and accepted for publication that documents the findings of the evaluations.	Original	
AS.3.5.10		Development of ASAS applications in procedural airspace	FY09Q4	Work complete in FY08.	Published paper or NASA TM on process to develop airborne based separation procedures, and a published paper on results from batch study of ITP.	Realignment	
AS.3.5.11		Mixed operations concepts formulated	FY10Q4	Number of concepts formulated.	Concepts documented and reviewed by non-advocate board	Realignment	
AS.3.5.12		Auto SA simulation: homogeneous airspace under nominal conditions	FY11Q3	SA performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data.	Technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	
AS.3.5.13		Auto SA simulation: mixed operations airspace under nominal conditions	FY12Q2	SA performance measures for efficiency, safety & capacity; human workload & situation awareness measures; subjective data.	Technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.5.14		Parametric RCNS	FY09Q4	Capacity, throughput, efficiency, safety, predictability.	At least one technical manuscript written and accepted for publication.	Realignment	
AS.3.5.15		HITL RCNS	FY10Q3	Capacity, throughput, efficiency, safety, predictability.	Technical manuscript written and accepted for publication.	Realignment	
AS.3.5.16		Develop approach for system validation / certification of SA systems and concepts	FY13Q3	Stakeholder vetting and peer review.	Technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	
AS.3.6.01		ASDO initial concept definition	FY07	N/A	Internal report minimum, conference paper preferred.	Original	Completed
AS.3.6.02	Critical	Refine algorithms and procedures for merging and spacing operations to a single runway	FY09Q4	<ul style="list-style-type: none"> - Spacing variation at threshold of less than 10 seconds under normal conditions; - Off-nominal events do not disrupt overall flow. 	Publication (or acceptance for publication) of NASA TM or at a technical conference.	Original	
AS.3.6.03		Evaluation of single airport operations using medium-term technologies	FY10Q4	For major airports, increase peak runway throughput by 5%, decrease mean flight time during descent by 1 minute, and attain 75% conformance to prescribed trajectories in nominal conditions.	Publication (or acceptance for publication) at a technical conference.	Original	
AS.3.6.04		Develop integrated operations for single airport	FY11Q1	For major airports, reduce mean delay by 25%.	Publication (or acceptance for publication) at a technical conference.	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.6.05		Evaluate single airport operations using late-term technologies	FY12Q4	For major airports, increase peak airport throughput by 15%, decrease mean flight time during descent by 2 minutes, and attain 90% conformance to prescribed trajectories in nominal conditions.	Publication at a technical conference minimum, journal preferred.	Original	
AS.3.6.06	Critical	Develop integrated operations for metroplex	FY12Q2	For metroplex, decrease flight time during descent by 2 minutes.	Publication (or acceptance for publication) at a technical conference.	Original	
AS.3.6.07		Evaluation of medium-term, human-centric, metroplex operations	FY13Q2	For metroplex, increase peak operations by 50%, reduce flight time during descent by 2 minutes, and attain 75% conformance to prescribed trajectories in nominal conditions.	Publication (or acceptance for publication) at a technical conference.	Realignment	
AS.3.6.08		Evaluation of late-term, automated-centric, metroplex operations	FY14Q1	For metroplex, increase peak operations by 100%, reduce flight time during descent by 3 minutes and attain 90% conformance to prescribed trajectories in nominal conditions.	Publication at a technical conference minimum, journal preferred.	Realignment	
AS.3.7.01		Conduct objective analysis of service provider and aircraft operator separation assurance methods	FY10	Stakeholder vetting and peer review.		Original	Cancelled Merged

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.7.02	Critical	Develop fast-time system-level simulation of NGATS technologies	FY10	The system-level simulation includes models of ASDO, SA, TFM, and DAC technologies.		Original	Cancelled Merged
AS.3.7.03		Develop tools for generating future demand scenarios and analyzing NGATS data	FY10	1x, 2x, and 3x demand scenarios can be generated. NGATS data analyses will generate metrics that answer critical NGATS questions.		Original	Cancelled Merged
AS.3.7.04		Develop prognostic safety assessment methods for systems and operations		Independent peer review research results with ARMD AvSP and two external technical associations, including JPDO. System safety assessment methods to cover 85% of 2008 baseline safety case parameters. Operations safety assessment methods to provide quantitative methods for runway incursions, pilot/controller workload, taxi time over active runways, and unacceptable wake encounters. Prognostic safety assessment method recognized by two regulator bodies as providing credible assessments.		Original	Cancelled

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.7.05		Identify system-level safety issues	FY11Q4	Vetting (SLDAST, RFA researchers) of safety risk screening results, for reasonableness.	Publication of research results in relevant conference or journal.	Original	
AS.3.7.06		Initial common definitions	FY09Q4	Completeness of common definitions set, with verified applicability/traceability to other NextGen-Airspace RFA's, and JPDO goals/objectives, and metrics. Broad and appropriate use by NextGen-Airspace Program RFA's in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper documenting the common metrics, demand sets and assumptions.	Realignment	
AS.3.7.07		Common definitions phase II	FY11Q1	Completeness of common definitions set, with verified applicability/traceability to JPDO goals/objectives, and metrics. Broad and appropriate use by NextGen-Airspace Program RFA's in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Program review of interim update to NextGen-Airspace Program governing set of common definitions set.		

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.3.7.08		Common definitions phase III	FY12Q3	Completeness of common definitions set, with verified applicability/traceability to JPDO goals/objectives, and metrics. Broad and appropriate use by NextGen-Airspace Program RFA's in their experiments, allowing apples-to-apples comparison with alternative concept approaches.	Published paper that documents the common metrics, demand sets and assumptions.	Realignment	
AS.3.7.09		System-level assessment I	FY10Q4	System-level capacity/delay.	Published paper on assessment results, integrated concept option descriptions.	Realignment	
AS.3.7.10		System-level assessment II	FY12Q4	System-level capacity and robustness.	Published paper on assessment results, integrated concept option descriptions.	Realignment	
AS.2.1.01		Develop scripting language and protocols for a common-trajectory-model architecture (in collaboration with U.S. (FAA) and European trajectory-prediction research organizations (Eurocontrol))	FY08	Trajectory modeling consistency for various concepts.	Lit search for AIDL and experimental plan for interoperability, panel chair for REACT workshop.	Original	Completed
AS.2.1.02		Formal methods for validation	FY09Q4	Trajectory accuracy metrics.	Paper on validation methodology.	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.1.03		Develop vertical and horizontal-profile algorithms to model complex combinations of trajectory constraints (stemming from NGATS 4D trajectory-based operations) involving multiple “simultaneous” constraints (e.g., path, speed, altitude, and/or time) for En route, Transition (to Terminal), and Terminal airspace. Validate algorithms for En route and Transition airspace	FY08	Trajectory accuracy parameters.	4D FMS demo, GenAlt work checked into CTAS baseline. and used by default.	Original	Completed
AS.2.1.04		Survey and advance algorithms for predicting and describing propagation of trajectory uncertainty	FY08	Algorithms account for effects of initial condition errors, aircraft dynamic model errors, and environmental variables.	Contractor report on uncertainty estimation toolbox.	Original	Completed
AS.2.1.05		Constraint management methods	FY09Q4	Trajectory prediction accuracy in 4 dimensions.	Software deliverables – 4D FMS - integrate constraint relaxation into a simulation, constraint relaxation for CTAS checked into baseline.	Original	
AS.2.1.06		Complex combinations of constraints	FY09Q4	Trajectory prediction accuracy in 4 dimensions.	Software deliverables – (4DFMS) multiple RTA capability, enhanced gen alt capabilities (constraint relaxation).	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.1.08		Trajectory uncertainty modeling for EDA	FY09Q4	Predicted meet-time distribution statistics at the meter point, predicted trajectory error distributions along the descent path.	Model the weight, winds, and performance errors for the three look-ahead times. In CTAS, calculate the meet-time and path performance errors based on the weight, wind, and performance error models.	Realignment	
AS.2.1.09		Trajectory uncertainty modeling	FY10Q4	Trajectory prediction accuracy, quantification of uncertainty in trajectory predictions.	Conference/Journal or White paper on TPUBS, application of trajectory uncertainty toolbox on CTAS.	Realignment	
AS.2.1.10		Tool for determining performance requirements	FY11Q4	Sensitivity of key concept performance indicators as a function of the performance of the underlying trajectory prediction, sensitivity of the performance of a TP as a function of the models, algorithms, and assumptions.	Demonstration of simulation platform for NEXTGEN concept/DST.	Realignment	
AS.2.2.01		Produce a comprehensive list of performance attributes corresponding to the list of candidate NGATS operational concepts	FY07	Operational performance attributes such as capacity, throughput, delays, predictability, flexibility, user preference, safety, workload, efficiency.		Original	Completed
AS.2.2.02		Working with industry and the JPDO Shared Situation Awareness IPT, produce a set of parametric performance models of CNS systems	FY07	Communication, navigation, and surveillance characteristics and operational parameters (e.g., delays, response time, navigation precision, bandwidth).		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.2.03		Group the performance attributes under RNP, RCP, RSP, or an advanced performance measure	FY08	Grouping of performance attributes.		Original	
AS.2.3.01		Candidate airspace allocation algorithms proposed		Number of candidate algorithms proposed.		Original	Cancelled
AS.2.3.02		Candidate airspace allocation algorithms validated		Number of candidate algorithms assessed, number of candidate algorithms validated.		Original	Cancelled
AS.2.3.03		Adaptable airspace algorithms	FY09Q4	Number of algorithms developed.	Publication, white paper, or report.	Realignment	
AS.2.3.04		Airspace redesign benefit analyses	FY09Q4	% delay recovered over current sector design, number of sectors, workload and capacity variance, corridor utilization.	Publication, white paper, or report.	Realignment	
AS.2.3.05		Adaptable airspace benefit analyses	FY10Q4	% delay recovered over current sector design, complexity and capacity variance, degree of airspace change, corridor utilization.	Publication, white paper, or report.	Realignment	
AS.2.3.06		Define flow corridors procedures	FY10Q4	Number of procedures defined.	Publication, white paper, or report.	Realignment	
AS.2.3.07		Dynamic terminal airspace I	FY11Q4	Number of algorithms, procedures developed.	Publication, white paper, or report.	Realignment	
AS.2.3.08		Flow corridor benefit analyses	FY12Q4	% delay recovered over current sector design, corridor utilization.	Publication, white paper, or report.	Realignment	
AS.2.4.01		Develop oceanic traffic flow optimization concepts	FY08	Efficiency, throughput, delays, predictability		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.4.02		An improved metric for airspace complexity is defined	FY09Q4	Statistical correlation between metric and airspace complexity.	Conference or white paper describing an improved metric for airspace complexity.	Original	
AS.2.4.03		Assess system-wide performance of oceanic traffic flow optimization concepts		Efficiency, throughput, delays, predictability.		Original	Cancelled
AS.2.4.04		Update and refine airspace early integrated TFM requirements for the airspace functions of the early integrated TFM		Identify interface control requirements for 85% of predictive throughput functionality to FY10 L4 "initial Airportal early integrated TFM". Airportal early integrated TRM concept functionalities to demonstrate 20% improvement in strategic decision optimization vs. capacity and throughput at 4 major airports over a 30 day period. Validate surface optimization requirements using 2010 OEP capacity and 3X forecast domain in fast-time simulation.		Original	Cancelled
AS.2.4.05		Initial weather translation models	FY12Q4	Demonstrate a 5% improvement in the ability to estimate the capacity of a weather impacted region of airspace over traditional approaches that assume capacity reduction is equal to the percent area covered by VIL ≥ 3 .	Conference or journal publication that describe the initial weather translation models.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.4.06		Refined weather translation models	FY14Q4	Demonstrate a 10% improvement in the ability to estimate the capacity of a weather impacted region of airspace over traditional approaches that assume capacity reduction is equal to the percent area covered by VIL ≥ 3 .	Conference or journal publication describing the testing and development of weather translation models over multiple time-horizons.	Realignment	
AS.2.5.01	PART	Strategic automated resolution and trajectory change technology	FY07	95% of traffic conflicts are detected and resolved prior to the 3-5 min to loss of separation point with overall resolution delays and near-miss separation characteristics that are comparable or better than that of today's operations while operating under a significant increase in traffic density (e.g., 2-3x) and in the presence of uncertainty and under a variety of traffic conditions.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.5.02		Initial operating concept options description for service-provider-based SA approach	FY07	Description of a range of operating concepts (2 or 3) that will be evaluated in human-in-the-loop simulations. Operating concept descriptions include required technology, primary operator (controller/pilot) tasks, general user interface characteristics, examples of relevant operational traffic scenarios during nominal and failure modes.		Original	Completed
AS.2.5.03		Initial service-provider-based automated separation assurance simulation	FY07	Provides opportunity for researchers and stakeholders (e.g., FAA, airlines, controllers, pilots) to gain initial insight and provide initial feedback by viewing operating concept with humans in the loop. Initial objective analysis of operating concept during nominal and failure recovery operations. Initial evaluation of methods for gathering and analyzing experimental data, including metrics collected in laboratory analysis, during human in the loop simulations.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.5.04		Tactical automated safety assurance trajectories	FY08	Tactical detection and resolution logic computes safe tactical trajectories and thereby prevents a loss of separation for the majority of those traffic conflicts (~95% of the 5% not solved strategically) that were not resolved by strategic automated resolution technology and thereby prevent loss of separation while operating under a significant increase in traffic density and in the presence of uncertainty and under a variety of traffic conditions.		Original	Completed
AS.2.5.05		Technology for determining weather impacts on tactical airspace operations	FY08	More useful/accurate characterization of weather impacts, ability to reduce lost usable airspace by 50% in some areas/conditions compared to today's operations.		Original	Completed
AS.2.5.06		Dynamic weather technology	FY10Q2	Fidelity of the convective weather representation.	Test report(s) written that document the V&V results for the convective weather representation capability in the relevant test bed(s).	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.5.07		Analysis of aircraft CNS performance as it relates to separation assurance technology	FY09Q4	Communications delays, negotiation delays, workload.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.2.5.08		Auto SA performance: complexity constraints	FY10Q4	SA performance measures for efficiency, safety, and complexity.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.2.5.09		Human workload, performance, and situation awareness analysis of higher levels of automation for service-provider-based separation assurance		Workload, performance (response time and error), and situation awareness.		Original	Cancelled Merged
AS.2.5.10		Identify failure modes for off-nominal studies	FY11Q4	Number of failure modes identified for each candidate operating concept to be evaluated in the functional allocation studies.	Technical report written that documents the method and results of the analysis.	Original	
AS.2.5.11		Laboratory integration of multiple SA algorithms into simulation test beds	FY10Q4	Number of algorithms integrated into each simulation test bed.	Test report(s) written that document the results for the respective algorithms that have been successfully integrated into the relevant test bed(s). Risk: May suffer loss of WYE support in FY09 due to expected FY10 reduction in contractor force on the order of 1/3 to 1/2.	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.5.12		Safety assessment for SA systems & concepts	FY12Q2	Number of hazards identified, depth of analysis of each hazard.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	
AS.2.5.13		Auto SA performance: dynamic weather constraints	FY11Q1	SA performance measures for efficiency and safety.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Realignment	
AS.2.5.14		Integration of CNS Performance Models into Simulation Test beds	FY09Q3	TBD	Technical manuscript written and accepted for publication (may be NASA internal).	Original	
AS.2.6.01		Flight validation of Low Noise Guidance (LNG)	FY07	Ground noise measurements, conformance to guidance, fuel burn.		Original	Cancelled
AS.2.6.02		Support for initial algorithm, procedures and information requirements for merging and spacing technology	FY07	Spacing variation at threshold of less than 10 seconds under normal conditions; off-nominal events do not disrupt overall flow.	Publication (or acceptance for publication) of NASA TM or at a technical conference.	Original	Completed
AS.2.6.03		Initial Sequencing and Deconfliction Algorithm	FY08	Throughput/capacity at major airports and regional/reliever airports, noise and emissions impacts, fuel use.	Internal report minimum, conference paper preferred.	Original	Completed
AS.2.6.04		Develop method for airborne maneuvering within established limits to make gross corrections to inter-aircraft spacing.	FY09			Original	Cancelled

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.6.05		Information and decision support requirements for terminal area operations	FY09Q3	Definition of information content, accuracy, and frequency to enable development of Metroplex scheduling tool that meets arrival, departure, and surface operations needs, as well as complies with metroplex airspace constraints.	Publication (or acceptance for publication) at a technical conference.	Original	
AS.2.6.06		Definition of data exchange requirements for Resource Scheduling Optimization	FY10Q3		Publication (or acceptance for publication) at a technical conference.	Original	
AS.2.6.07	Critical	Procedures and technologies for initial ASDO concept of operations in simple airspace	FY11Q3	* Metric will vary based on the type of procedure being researched, and the intended goal of that procedure.	Technical conference publication minimum, journal preferred.	Original	
AS.2.6.08		Develop ASDO operations that leverage advanced FMS and enhanced control guidance	FY11Q2	For major airports, reduce fuel usage and emissions by 5%, noise by 1dB, and increase conformance of aircraft to prescribed trajectory by 5% while maintaining throughput.	NASA TM or technical conference publication minimum, journal preferred.	Original	
AS.2.6.09		Develop concept of use for automated tactical conflict avoidance function	FY10Q1	Achieve concurrence from Project researchers and SME's that all fundamental requirements are present.	Publication (or acceptance for publication) at a technical conference.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.6.10		Fast time simulation assessment of automated tactical conflict avoidance algorithm	FY10Q3	Achieve false alert rate less than 10% and missed alert rate less than 5% for dense terminal airspace.	Publication at a technical conference minimum, journal preferred.	Realignment	
AS.2.6.11		Initial flight deck evaluation of automated tactical conflict avoidance function	FY11Q3	Marginally acceptable ratings for workload and situational awareness. Achieve false alert rate less than 5% and missed alert rate less than 1% for dense terminal airspace.	Publication (or acceptance for publication) at a technical conference.	Realignment	
AS.2.6.12		High fidelity flight deck evaluation of automated tactical conflict avoidance function	FY13Q2	Acceptable ratings for workload and situational awareness. Achieve false alert rate less than 1% and missed alert rate less than 1% for dense terminal airspace.	Publication at a technical conference minimum, journal preferred.	Realignment	
AS.2.6.13		Develop scheduling capability for static RNAV/RNP operations into dense terminal airspace including efficient descents	FY10Q2	For major airports, reduce flight time during descent by 2 minutes and enable 75% of arrivals to execute user-preferred descent profile.	Publication (or acceptance for publication) at a technical conference	Realignment	
AS.2.6.14		Develop off-nominal recovery methods for highly-automated SDO concept option	FY11Q3	Reduction of terminal delay in off-nominal scenarios of 50%. Reinsertion of non-conforming aircraft with 90% success before conflict avoidance layer.	Technical conference publication minimum, journal preferred.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.7.01		Develop method for modeling human workload in fast-time simulations; validate models against workload measurements	FY10Q4	Method reduces the uncertainty bounds by 50% for typical Air Midas analyses.	Publication of research results in relevant conference or journal.	Original	
AS.2.7.02		Develop predictive, conceptual-level, safety assessment method for ill-defined complex interacting systems (including the NAS.)	FY11	Stakeholder vetting and peer review by CAST.		Original	Cancelled Merged
AS.2.7.03		DAC-TFM design study I	FY10Q2	Vetted (SLDAST, DAC, & TFM) design study results (capacity, delay and efficiency at a minimum) from simulation of DAC-TFM interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents DAC TFM interactions.	Realignment	
AS.2.7.04		DAC-TFM design study II	FY13Q3	Vetted (SLDAST, DAC, & TFM) design study results from simulation of DAC-TFM interacting in a common simulation environment. Add robustness to weather, to capacity, delay and efficiency metrics.	Published paper on assessment results, integrated concept descriptions that documents DAC TFM interactions.	Realignment	
AS.2.7.05		SA-TFM design study I	FY10Q4	Vetted (SLDAST, SA, TFM) design study results (capacity, delay and efficiency at a minimum) from simulation of SA-TFM interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents SA TFM interactions.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.7.06		SA-TFM design study II	FY11Q4	Vetted (SLDAST, SA, TFM) design study results from simulation of SA-TFM interacting in a common simulation environment. Add robustness to weather, to capacity, delay and efficiency metrics.	Published paper on assessment results, integrated concept descriptions that documents SA TFM interactions.	Realignment	
AS.2.7.07		SA-TFM design study III	FY13Q2	Vetted (SLDAST, SA, TFM) design study results from simulation of SA-TFM interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents SA TFM interactions.	Realignment	
AS.2.7.08		ASDO-Airportal design study I	FY11Q3	Vetted (SLDAST, ASDO, Airportal) design study results (capacity, delay and efficiency at a minimum) from simulation of ASDO-Airportal concepts interacting in a common simulation environment.	Published paper on assessment results, integrated concept descriptions that documents ASDO-Airportal interactions.	Realignment	
AS.2.7.09		ASDO-Airportal design study II	FY13Q3	Vetted (SLDAST, ASDO, Airportal) design study results from simulation of ASDO-Airportal concepts interacting in a common simulation environment. Add robustness to weather, to capacity, delay and efficiency metrics.	Published paper on assessment results, integrated concept descriptions that documents ASDO-Airportal interactions.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.7.10		Human Factors Assessment I	FY09Q4	Prioritized list of NextGen human performance issues, vetted by relevant human performance research community (e.g. composite University, NASA, FAA) for thoroughness (breadth & depth).	Publication of research results in relevant conference or journal.	Realignment	
AS.2.7.11		Define candidate updates to FAA's Multi-Sector Planner (MSP) midterm concept of operations (ConOps.)	FY09Q4	Vetted (with DAC, SA, ASDO, & TFM) list of candidate MSP Midterm ConOps updates.	Published white paper describing possible extensions to MSP Mid-Term Conops for 2018, specifically calling out significant areas of overlap or potential integration with SA, TFM, DAC and/or ASDO research.	Realignment	
AS.2.7.12		Determine feasibility and benefits of one or more candidate MSP updates identified in AS.02.07.11	FY10Q4	Vetted study results (with RFA's associated with concepts analyzed) of benefits with/without MSP in terms of (e.g.): airspace throughput, workload, flight efficiency, number of conflicts, number of clearances issued.	Published study results in a relevant conference, journal, or NASA publication.	Realignment	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.2.7.13		MSP requirements for the mid-term NAS	FY11Q4	Vetted (with NextGen Project Leaders) mid-term MSP operational requirements (technical and conceptual), along with recommendations for how requirements might change with introduction of future NextGen capabilities and operations.	Published study results in a relevant conference, journal, or NASA publication.	Realignment	
AS.1.1.01		Survey and document the current SOA of trajectory prediction/modeling algorithms and software capabilities and the requirements envisioned for trajectory prediction to support NGATS automation systems	FY07	Current SOA reported and documented.	Draft documents detailing capabilities for existing tools, five documents delivered.	Original	Completed
AS.1.1.02		Survey and document the trajectory prediction/ modeling algorithms and software capabilities (e.g., EDA, PARR, 4D-FMS) supporting the current state of the art (TMA, URET, FMS), and requirements envisioned for future TP capabilities to support NGATS-relevant trajectory prediction for the early integrated TFM and related automation	FY07	Trajectory accuracy parameters.	Presentation on developing requirements for new tools.	Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.1.03		Develop algorithms for measuring the difference between 4D trajectories	FY07	Algorithms developed with sufficient sensitivity to identify differences between actual vs. predicted trajectories, FMS vs. ground-tool trajectory predictions, and U.S. vs. European trajectory specifications.		Original	Completed
AS.1.1.04		Identify and quantify a complete set of constraints and objective functions typically applied to trajectories to support ATM functions	FY07	Constraints and objective functions documented from DAC, TFM, SA, and ASDO. Quantification includes typical values, bounds, or conformance precision, as appropriate to the ATM function.	Paper on abstraction techniques.	Original	Completed
AS.1.1.05		Identify and quantify sources of uncertainty for trajectory prediction	FY07	Characterization of trajectory prediction uncertainty includes sensitivities to wind prediction uncertainty, aircraft aero/engine performance variables, auto-flight mode, RNP, crew procedures, and flight segment type.		Original	Completed
AS.1.1.06		Develop data mining techniques for identifying trends in trajectory intent error	FY08	Techniques validated to accurately identify trends in at least 80% of known trajectory intent errors from a current-day validation data set.	Paper on data mining of intent errors GN&C 2008.	Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.2.01		Identify suitable techniques for modeling RTSP performance characteristics	FY09Q1	The metrics include comprehensiveness and peer review acceptance.		Original	
AS.1.2.02		Synthesis of human factors and operational literature	FY08	The metrics are the comprehensiveness of human performance characteristics.		Original	Cancelled
AS.1.2.03		Extensions of analytical and statistical techniques for modeling RTSP performance characteristics		The metrics are the techniques explored are of sufficient maturity to construct parametric models for RTSP for use in modeling and simulation.		Original	Cancelled Merged
AS.1.2.04	Critical	Identify grouping techniques that will classify/represent the multi-dimensional nature of RTSP performance characteristics. Identify decision support and information presentation techniques applicable to grouping techniques	FY10	The metrics are the grouping characteristics (robustness, consistency, sensitivity, and face validity).		Original	
AS.1.3.01		The state of the art is surveyed and documented	FY07	Breadth and depth of survey.		Original	Completed
AS.1.3.02		The elements of airspace structure in the NAS are inventoried, and “Best Practices” in airspace design are documented. Adapt for NGATS	FY07	Breadth and depth of inventory.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.3.03		Utilize formal mathematical methodologies, such as genetic algorithms and neural networks, to develop dynamic airspace structures supporting both new and conventional classes of airspace		Number and type of airspace units within the NAS.		Original	Cancelled
AS.1.4.01		Develop empirical and data mining models for correlating weather and key metrics for NAS performance. The milestone will be evaluated in terms of improvements in estimating NAS delay over current methods	FY08	This research should improve our ability to estimate aggregate delay based on predicted weather and expected traffic to within 10,000 minutes based on 2006 traffic levels.		Original	Completed
AS.1.4.02	\	Assess and develop aggregate models, such as network flow and linear time varying models, for traffic flow under nominal and off-nominal conditions	FY08	The aggregate models should demonstrate a 10 times reduction in the size of the models used for analysis.		Original	Completed
AS.1.4.03		Characterize current and future ATM systems by adapting concepts from network and graph theory	FY08	The success of this milestone will be measured by its ability to characterize the new ATM network with a higher level of varying demand than today.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.4.04		Expand the concept of traffic complexity to controller, pilots and varying levels of automation	FY08	The metric for this research is the increase in the ability to define traffic complexity from the current state of the art and expand it to pilots and varying levels of automation.		Original	Cancelled Merged
AS.1.4.05		Develop probabilistic and stochastic methods for flow management to address uncertainties in weather prediction. Metric used will be improvements over current deterministic methods	FY10	The probabilistic methods should demonstrate a 10% improvement in the aggregate system delay or other appropriate system measures over deterministic methods.	Conference or journal publication describing probabilistic or stochastic flow management algorithms, concepts, models for managing individual flights or flows of flights in the presence of system uncertainties.	Original	
AS.1.4.06		Develop linear/nonlinear/dynamic programming and decomposition methods for advanced traffic flow management	FY11	The decomposition methods are aimed at achieving a real-time planning capability (two minutes for a six-hour planning horizon) for NAS-level TFM problems.	Conference or journal publication describing the linear/nonlinear/dynamic programming and decomposition methods developed in support of this milestone.	Original	
AS.1.5.01		Alternative criteria for minimum separation standards	FY11Q2	Number of alternative constructs proposed and evaluated Reduction in risk and/or increase in capacity associated with a given construct.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.1.5.02		Methodology for analysis of tactical ATC and airborne collision avoidance interaction	FY08	Method developed and validated with actual air traffic data in the presence of uncertainties.		Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.5.03		Analytical methods to assess system response to failure events	FY09Q4	Method developed and validated with actual air traffic data in the presence of uncertainties.		Original	
AS.1.5.04		Methods for quantifying safety level of human operators in ATM system	FY08	Method developed and validated in simulation in the presence of uncertainties.		Original	Cancelled
AS.1.5.05		Verification and validation methodologies for SA algorithms and software	FY12Q2	Code coverage, path coverage, V&V time, V&V cost, software robustness.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.1.5.06		Formal proof of separation assurance for oceanic applications	FY07	Completeness.		Original	Completed
AS.1.5.07		Recommended complexity metric	FY08	Number of machine operations.		Original	Completed
AS.1.5.08		Verification and validation technologies for analysis of N-aircraft SA algorithms	FY11Q2	Number and scope of assumptions required to complete the proof.	At least one technical manuscript written and accepted for publication that meets the research objective as stated in the milestone description.	Original	
AS.1.5.09		RCNS parameter definition	FY10Q4	Suggested definitions for future CNS performance requirements	Technical manuscript written and accepted for publication (may be NASA internal).	Realignment	
AS.1.5.10 formerly PBS AS.1.2.03		Extensions of analytical and statistical techniques for modeling RTSP performance characteristics	FY10Q2	Techniques are sufficiently mature to construct parametric models for RTSP for use in modeling and simulation.	Technical manuscript written and accepted for publication.	Realignment	Merged
AS.1.6.01		Characterize and quantify the uncertainty impact of ASDO procedures	FY08	N/A	Internal report minimum, conference paper preferred.	Original	Completed

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.6.02		Investigate scheduling and rationing algorithms for weather impacted NAS resources	FY09Q4	Decrease weather induced delay by 30%.	Publication at a technical conference minimum, journal preferred.	Original	
AS.1.6.03		Develop advanced FMS guidance and control algorithms to enable late-term ASDO operations	FY10Q2	Reduce fuel usage during high density terminal operations by 5% while increasing the percentage of aircraft achieving stabilized approach criteria by 5%.	1) ATOL upgraded with eNAV capability by July 2009. 2) NASA TM or technical conference publication by summer of 2010.	Original	
AS.1.6.04		Explore innovative guidance and control methods for the super density terminal environment		Review of guidance and control methods, their strengths and weaknesses.		Original	Cancelled
AS.1.6.05		TRACON operational error analysis	FY09Q4	Detect all provided operational errors at least 2 minutes ahead of time.	Publication (or acceptance for publication) at a technical conference.	Realignment	
AS.1.7.01	Critical	Develop initial system-level Con-Ops. Leverage JPDO NGATS Con-Ops, and expand development as required, to support Airspace Systems Program (Airspace & Airportal) research, and concept development.	FY07	Completeness by containing JPDO (stakeholder) and technologist views on separation assurance, demand/capacity imbalance and airspace modifications.		Original	Completed
AS.1.7.02		Research game theoretic concerns related to NextGen system operation	FY10Q4	Project review of gaming scenarios considered, and concurrence that primary gaming issues have been considered/addressed.	Publication of research results in relevant conference or journal.	Original	

Milestone ID	Key Milestone	Milestone Title	Scheduled Completion FYQ	Planned Metric	Exit Criteria	Milestone Status	
AS.1.7.03	Critical	Develop individual agent-based models of NextGen technologies	FY08Q4	These models shall include at least ASDO, TFM, SA, and DAC.	Document agent-based model development (completed models and planned models). Publish available capabilities in relevant conference or journals.	Original	Completed
AS.1.7.04		Develop interim system-level concept of operations to accommodate 3x demand based on results of studies and identified gaps	FY09Q4	Less than 50% change from initial version and stakeholder vetted.		Original	Cancelled
AS.1.7.05		Develop approach for system validation and certification methodology		Results for AAC, ASAS, and TCAS algorithms.		Original	Cancelled Merged
AS.1.7.06		Define minimal constraint/data for systemic control	FY10	Design constraint fields that span no more than 15% of the adjoining time horizons.		Original	Cancelled

B-2. Milestone Schedule FY2009 – FY2014

Appendix B-2 contains the milestone schedule for FY2009 – FY2014.

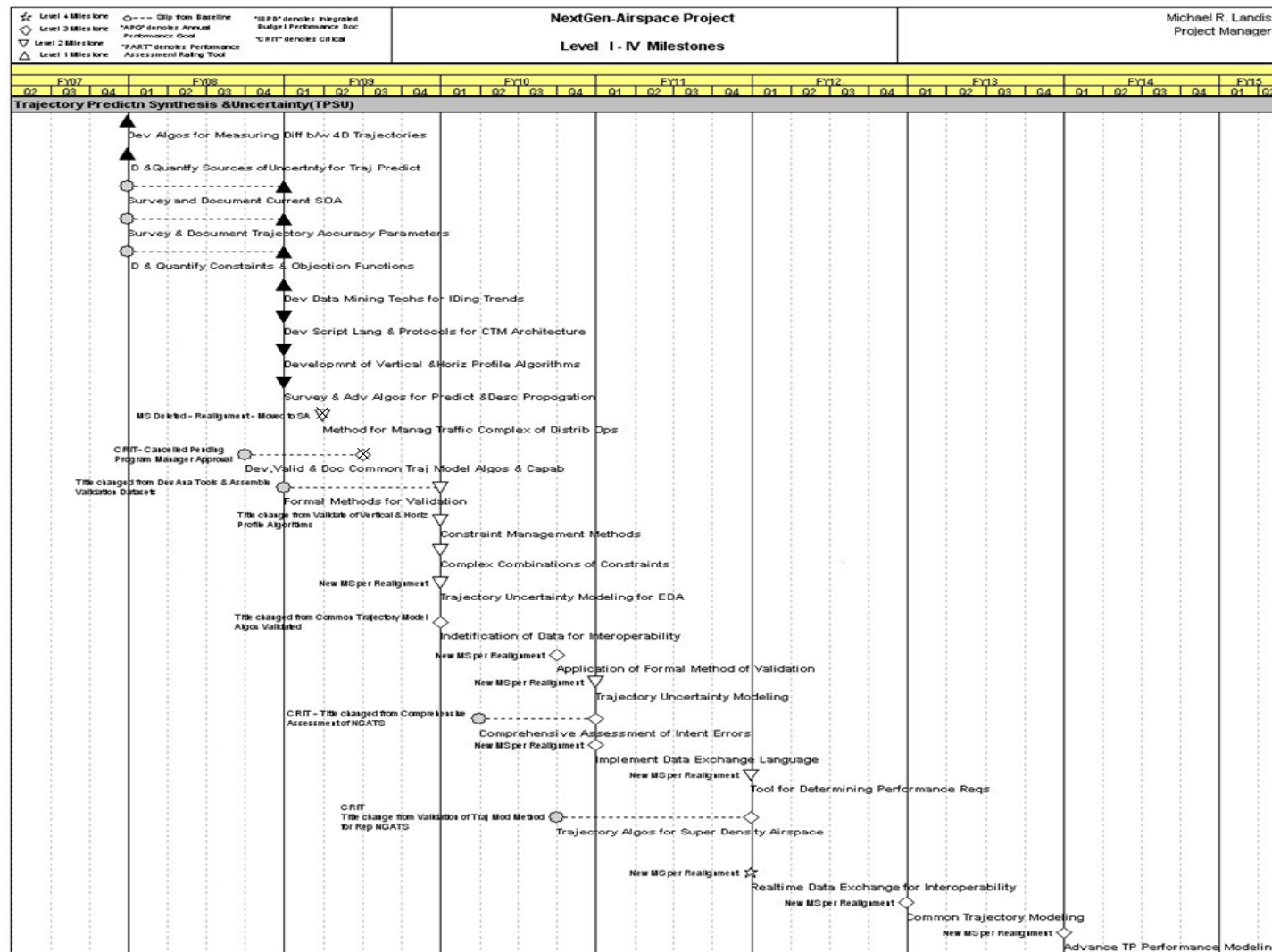


Figure 3. Trajectory Prediction Synthesis and Uncertainty Milestone Schedule FY2009 – FY2014

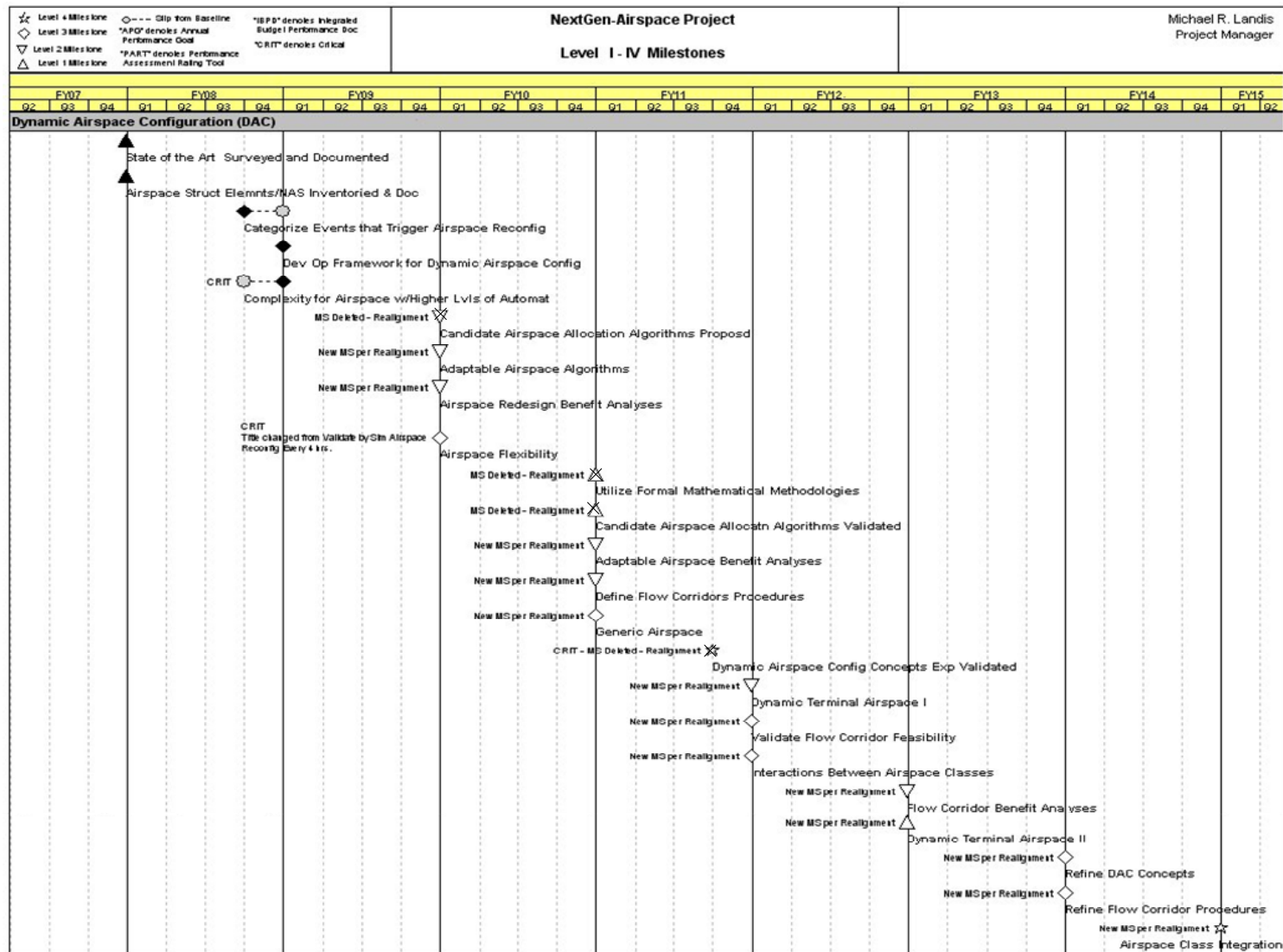
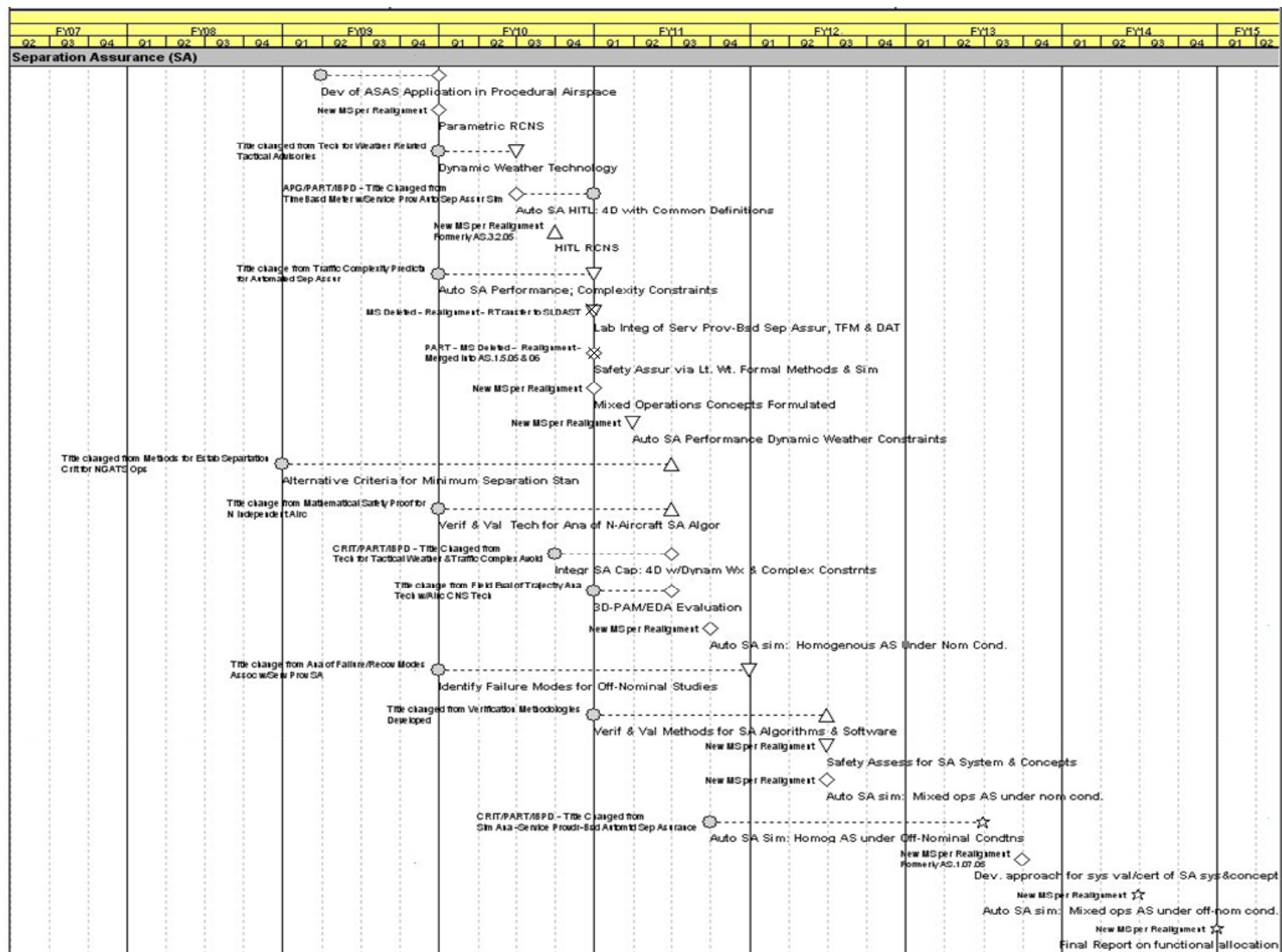


Figure 4. Dynamic Airspace Configuration Milestone Schedule FY2009 – FY2014



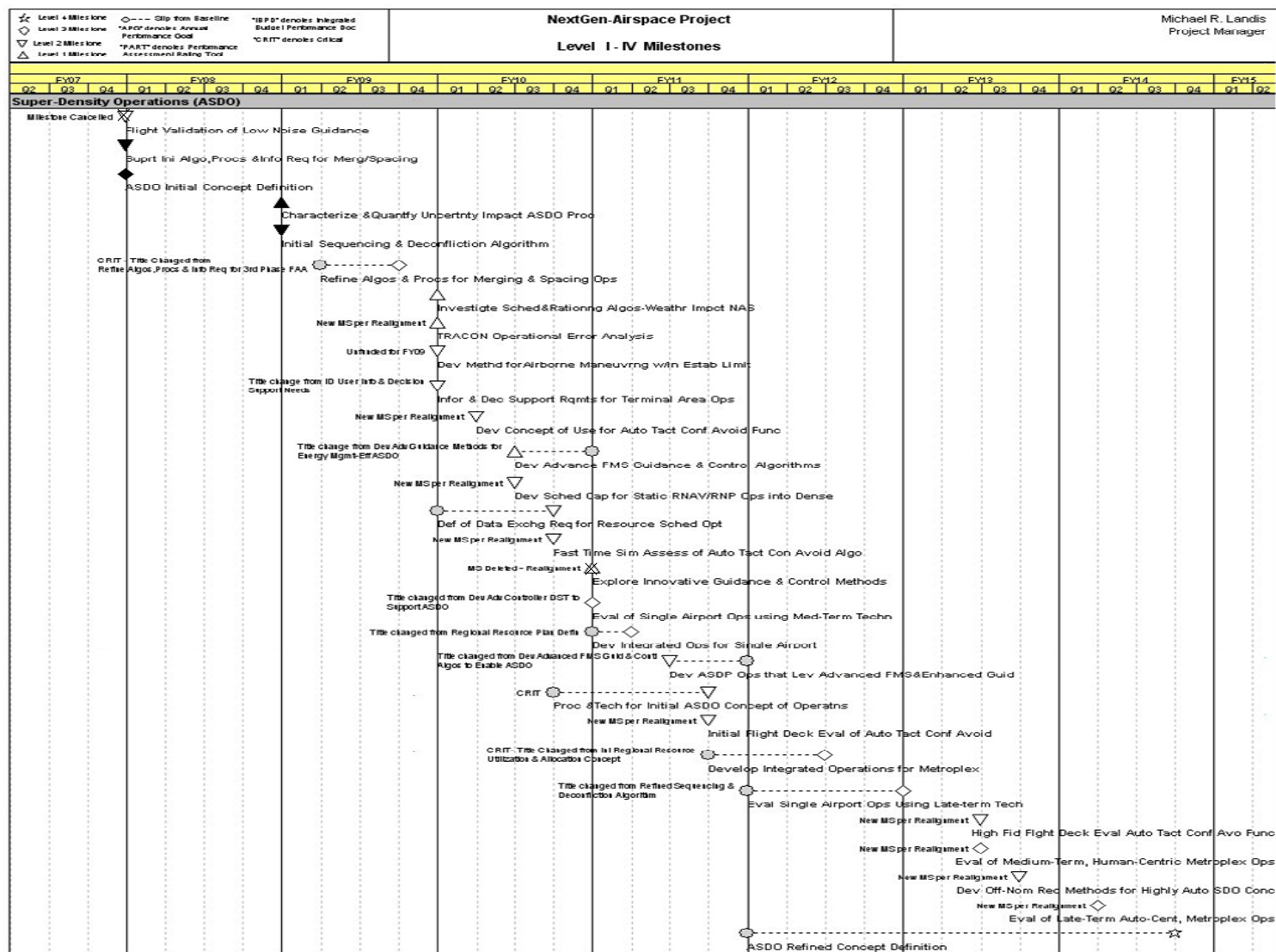


Figure 6. Airspace Super Density Operations Milestone Schedule FY2009 – FY2014

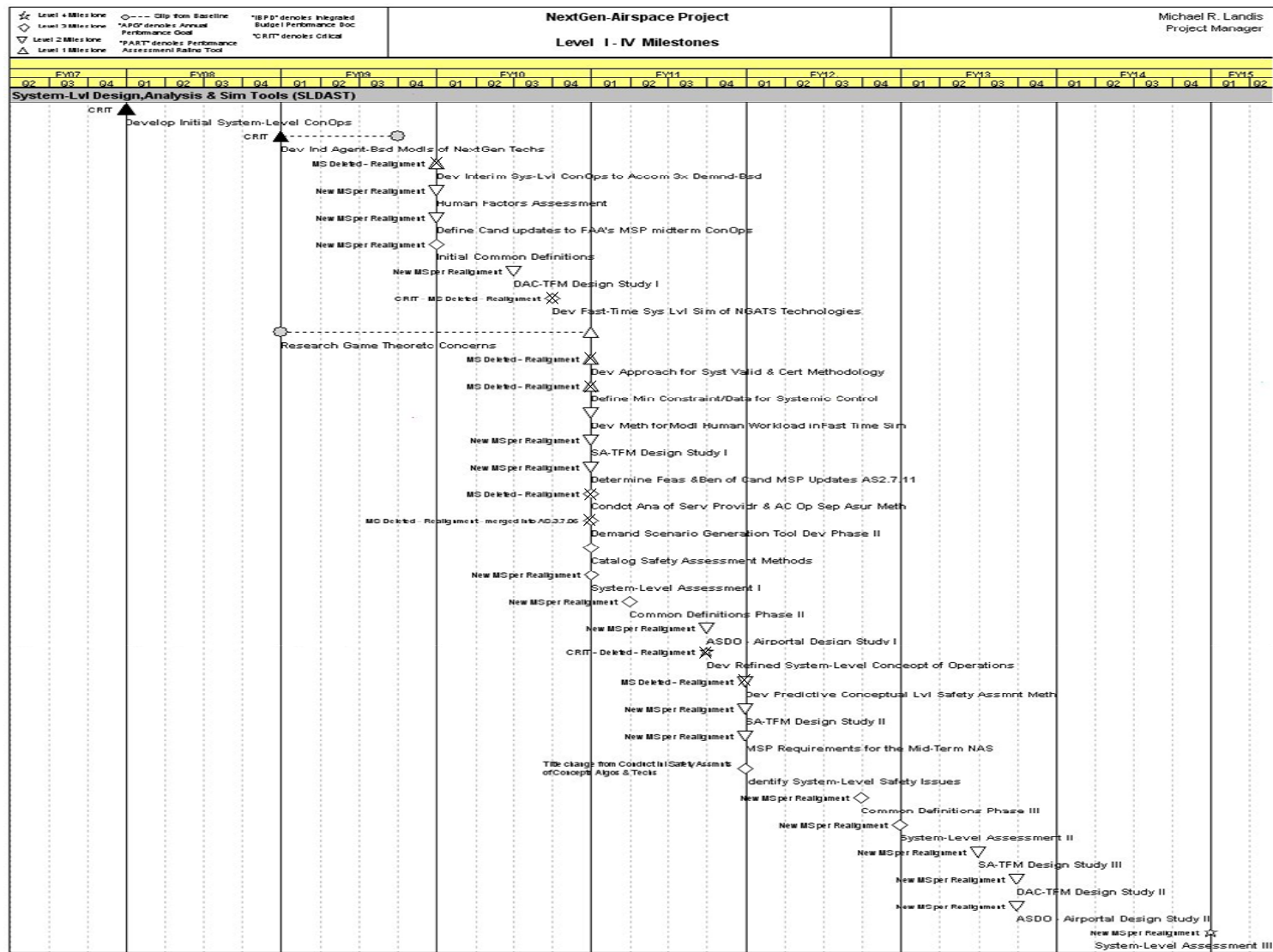


Figure 7. System-Level Design, Analyses, and Simulation Tools

B-3. Key Milestones for FY2009 – FY2011

NASA utilizes two sets of performance measures. The first is the Integrated Budget and Performance Document (IBPD). Within the IBPD are Annual Performance Goals (APG). The second set of performance measures are included in the Performance Rating Tool (PART) which is an Office of Management and Budget (OMB) tool. Appendix B-3 contains a listing of key milestones for each RFA planned for FY2009 – FY2011. The Project tracks key milestones at the Program and Directorate level according to the following designations:

- Critical = Milestones provided by the Project and Program in response to Congressional Questions for the Record 2007.
- PART = Performance Assessment Rating Tool. The PART is OMB's agency performance measurement process.
- IBPD = Integrated Budget Performance Document. The IBPD is NASA's internal reporting document. It is also a section within the NASA Budget.
- APG = Agency Performance Goal. The APG is an element within the Agency Performance and Accountability Report and a subset of the IBPD.

Table 8. Key Milestones for FY2009 – FY2011

	Critical	Part	IBPD	APG
FY09	AS3.1.03	AS3.5.05	AS3.5.05	AS3.5.05
	AS3.2.04			
	AS3.3.04			
FY10	AS3.1.04	AS3.5.06	AS3.5.06	AS3.4.04
	AS1.2.04	AS3.5.07	AS3.5.07	AS3.5.06
	AS3.4.05	AS3.5.08		
	AS3.5.07			
	AS2.6.07			
	AS3.7.02			
FY11	AS4.3.01	AS4.5.01	AS4.5.01	TBD
	AS4.4.01			
	AS4.5.01			
	AS3.6.06			

APPENDIX C. NEXTGEN-AIRSPACE PROJECT ROLES AND RESPONSIBILITIES

Appendix C contains descriptions of roles and responsibilities for the following positions:

- C-1. Principal Investigator (PI)
- C-2. Project Manager (PM)
- C-3. Project Scientist (PS)
- C-4. Associate Principal Investigator (API)
- C-5. Associate Project Manager (APM)
- C-6. Research Manager
- C-7. Researchers, Technicians, Scientists, and Support Personnel
- C-8. Business Team
- C-9. NRA Manager
- C-10. Assumptions

C-1. Principal Investigator Working with Associate Principal Investigators

The Project PI is responsible and accountable to the Director of the Airspace Systems Program for technical and resource planning and execution. Primary responsibilities include:

- Assume overall responsibility for the success of the Project.
- Assume final authority for technical content, including:
 - Agreement with milestone description, success metrics, exit criteria provided by APIs;
 - Annual agreement with Milestone Record and tasks proposed by the APIs.
- Provide technical guidance to the APIs, as needed.
- Work with the JPDO to align Project goals with NextGen requirements.
- Assume primary responsibility for tracking technical progress toward milestone completion (assisted by the PM and the PS).
- Provide the primary external interface for the Project, including:
 - Represent overall Project work to Program office, other ARMD project PIs, the JPDO, other government agencies, industry, and academia.
 - Work with PM to arrange partnerships involving the entire Project or multiple RFAs with other government agencies, industry, and academia
 - Serve as interface for international agreements between the Program office and Project-level initiators.

C-2. Project Manager Working with Associate Project Managers

The PM is responsible and accountable to the PI for Project planning and execution. Primary responsibilities include:

- Maintain accountability to the PI in executing the programmatic requirements of the Project. Serve as project management POC to the Airspace Systems Program Office concerning budget, workforce acquisition strategy, management practices, and schedule.
- Serve as the Project's business POC for agreements with industry and other government agencies.
- Assume responsibility for the planning, development, and management of the Project's reporting, documentation, integrated master scheduling, and resource performance.
- Develop and oversee the acquisition strategy in support of the PI.
- Work with the APMs and project scheduler to establish an integrated master schedule for the Project to show:
 - Progress toward meeting milestones
 - Major project activities
- Manage and account for Project resources, working with APMs and budget analysts.
- Establish and lead an inter-center business management team to provide reporting, communications, and financial integration.

C-3. Project Scientist Working with Principal Investigator

The PS serves as a technical authority and is responsible and accountable to the PI for the integrity of the Project's technical plans. Primary responsibilities include:

- In the absence of the PI, assume overall technical responsibility for the NextGen-Airspace Project.
- Work with the APIs to track technical progress toward milestones, providing technical guidance when necessary.
- Maintain accountability to the PI for the technical integration of the Project.
- Lead development of the technical integration strategy by working with SLDAST APIs.
- Establish strategic goals and objectives for technical integration.
- Develop technical processes and communication methods for intra- and inter-Project integration.
- Work with the integration managers and project leaders in the Aviation Safety Program and the Fundamental Aeronautics Program to facilitate cross-project and cross-program integration.
- Work with the APIs to implement integration processes throughout the NextGen-Airspace Project.

- Work with the JPDO Systems Modeling and Analysis Division (SMAD) and the JPDO Evaluation and Analysis Division (EAD) and others at the JPDO to ensure integration strategies align with JPDO needs.
- Recommend strategies to increase collaboration and to mitigate barriers to collaboration across RFAs and Centers.
- Assist APIs in developing technical plans and activities that align with Project goals.

C-4. Associate Principal Investigator Working with Research Team (Including Research Manager)

The API is responsible and accountable to the PI for supporting the technical content and the contract execution of the Milestone Records for each RFA. Primary responsibilities include:

- Sign Milestone Records with the APM and research manager/facility manager, in concurrence with the PI.
- Lead technical planning, working with the research manager and the APM.
- Manage the technical progress of the Project and report status to the PI, PM, and PS.
- Evaluate the results of the technical plan.
- Resolve technical issues within the technical plan and provide recommendations to the PI and PS for redirection based upon lessons-learned.
- Provide modifications to the technical requirements of current Milestone Record tasks, as required, or work with the research manager and the APM to devise alternative(s).
- Serve as subject matter expert (SME) advising the PI, PS, and PM, as required.
- Lead formulation and selection of NRA topics for his/her research area.

C-5. Associate Project Manager Working with Project Manager Across Centers and with Business Teams

The APM is responsible and accountable to the API for supporting Milestone Record execution across Centers. Primary responsibilities include:

- Sign the Milestone Record with the API and research manager, in concurrence with the PI.
- Manage implementation cost, schedule, and workforce allocations at the RFA-level with the API.
- Resolve resource barriers (e.g., procurement acquisitions and funding flow).
- Resolve schedule burdens (e.g., facility access).
- Recommend strategies and solutions for executing tasks efficiently and effectively based upon constraints. Work with the PM, PI, PS, and API to modify implementation requirements to address progress impediments of a technical nature. Work with the PM and PI to modify implementation requirements to address progress impediments of a resource nature.

C-6. Research Manager

The research manager is accountable to the API to support the implementation of Milestone Record tasks and activities at the respective Centers. Primary responsibilities include:

- Sign the Milestone Record tasks with the API and APM, in concurrence with the PI.
- Foster an environment that encourages technical excellence.
- Support development of skills and capabilities in personnel to support ARMD programs.
- Provide workforce and facilities to implement the tasks.
- Monitor task implementation to achieve a level of awareness of subordinates' work and technical objectives of specific tasks.
 - Provide insight into impediments to progress that require Program and Center coordination to achieve success.
 - Provide insight into technical issues that may result in a Center Independent Technical Authority process.
 - Monitoring functions will include approval of purchase requests, travel orders, WebTADS, and award of contracts/tasks (e.g., performance-based contract) as defined within the Milestone Record tasks.
- Resolve issues of an internal nature (i.e., facility-use conflicts, workforce challenges, etc.) with the Center POC and notify the APM.
- Work with the API and APM to modify Milestone Record tasks, as appropriate.
- Work with the APM to resolve implementation impediments to success. Work with the API and APM to modify Milestone Record tasks, as appropriate.

C-7. Researchers, Technicians, Scientists, and Support Personnel

Researchers, technicians, scientists, and support personnel with day-to-day responsibilities are accountable to the API/APM for execution of the research in support of Milestone Record tasks. Primary responsibilities include:

- Identify and communicate impediments to the execution of research tasks to the research manager and API for resolution. Enable, through communication, the research manager to maintain a level of awareness of research activities.
 - Resolve technical impediments with the API and research manager.
 - Resolve implementation impediments with the APM and research manager.
- Participate in technical forums and conferences to share knowledge gained within execution of the Project.
- Publish technical peer-reviewed papers.
- Understand overall tasks and propose ideas and alternatives to improve task execution and Project quality and impact.

C-8. Business Team

The business team works with the PM to provide reporting and analysis of resources (workforce and dollars) and schedule. Business team members are assigned directly to the Project. The roles below describe functions important to project operations. Within a given project, a single individual may fill several of roles. Full discretion is vested in the PM to determine how this will be achieved in the best interest of the Project. Only the resource analyst is a full FTE per project. The business team consists of the following:

- Resource/Budget Analyst
 - Assist in budget development, service pool, and workforce planning across all Centers. Track budget. Provide timely budget and workforce analysis as requested by the PM and APM. Assist the PM and APM in the identification and timely resolution of budget and workforce issues. Assist in the development of the Program Operating Plan and phasing plans and all phases of the budget cycle. Work closely with the Center Chief Financial Officer.
- Scheduler
 - Provide the NextGen-Airspace Project schedule, as requested by the PM and/or PI. Implements schedule changes and maintain updates. Advise the PM and PI on schedule improvements. Solicit necessary data from Project personnel for schedule development and updates.
- Risk Manager
 - Develop resource and schedule risk management strategies and makes recommendations to the PM to enable research success.
- Project Operations
 - Provide support to the project management team including maintaining and archiving Project documentation. Provide configuration control of critical Project documentation. Provide and/or coordinate support for responding to ARMD actions. Serve as primary assistant to the PM.

C-9. NRA Manager

- The NRA Manager is the COTR for the NextGen Airspace Project's NRA contracts, cooperative agreements, and other contracts and agreements. Primary responsibilities include:
 - Interact frequently with NextGen-Airspace Project management, the Contracting Officer (CO), contractor management, NASA technical organizations, and the NASA Shared Services Center (NSSC).
 - Direct the preparation and review of procurement documents prior to review by the CO and/or release to the NSSC.
 - In conjunction with contract technical monitors, monitor contractor activities to ensure compliance with technical, financial, delivery and other terms of the contract. Assess contractor performance.

- Collect, review, and enter data into the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) database. Prepare and distribute NSPIRES data to the APIs.

C-10. Assumptions

- The API and PS report to the PI. The API may support more than one project and may or may not be full-time on ARMD projects. The API and PS must be committed at least halftime to the Project.
- The PM and PS report to the PI.
- The APM reports to the PM and supports one or more APIs.
- A researcher works with the APM to report progress to API, PI, PS, and PM.
- A research manager (i.e., NASA Branch Chief or Division Chief) supervises the researcher.
- The Center POC office may supervise the research manager.
- The API and APM may be supervised by the research manager but are not directly supervised by the Center POC.
- The API, APM, PI, PM, and PS cannot hold a supervisory position.
- The PI, PM, and PS are not supervised by the research manager or the Center POC.
- Business team members are not directly supervised by the Center POC.

Performance reviews for PI, PM, and PS are handled at the Centers with input from the Program Director.

APPENDIX D. ACRONYMS AND ABBREVIATIONS

3D-PAM	three-dimensional (latitude, longitude and altitude) path arrival management
4D	four-dimensional (latitude, longitude, altitude, and time)
4D-ASAS	four-dimensional airborne separation assurance system
AA	Associate Administrator
AAC	Advanced Airspace Concept
ACES	Airspace Concept Evaluation System
AFRL/IF	Air Force Research Laboratory, Information Directorate
AMI	Airportal and Metroplex Integration
AOL	Airspace Operations Laboratory
API	Associate Principal Investigator
APG	Annual Performance Goals
APM	Associate Project Manager
ARC	Ames Research Center
ARMD	Aeronautics Research Mission Directorate
ASDO	Airspace Super-Density Operations
ASP	Airspace Systems Program
ASTOR	Aircraft Simulation for Traffic Operations Research
ATC	air traffic control
ATM	air traffic management
ATOL	Air Traffic Operations Laboratory
ATOS	Airspace and Traffic Operations Simulation
ASA	automated separation assurance
ATSP	air traffic service providers
AvSP	Aviation Safety Program
CADOM	Coordinated Arrival and Departure Operations Management
CAST	Commercial Aviation Safety Team
CDM	collaborative decision making
CFO	Chief Financial Officer
CMF	Cockpit Motion Facility
CNS	communication, navigation and surveillance
COMM/OBL/ACCR	commitments/obligations/accruals
COTR	Contracting Officer Technical Representative
CS	civil servant
CVSRF	Crew-Vehicle Systems Research Facility
DAC	Dynamic Airspace Configuration
DOD	Department of Defense
DOT	Department of Transportation
DPI	Deputy Principal Investigator
DST	decision support tools
FAA	Federal Aviation Administration
FACET	Future ATM Concept Evaluation Tool
FAF	final approach fix

FDDRL	Flight Deck Display Research Laboratory
FTE	full time equivalent
EDA	En Route Descent Advisor
FMS	flight management systems
FTE	full-time equivalent
FY	fiscal year
GDP	gross domestic product
HLA	high level architecture
HITL	human-in-the-loop
IBPD	Integrated Budget and Performance Document
INC	including
IP	intellectual property
IPT	Integrated Product Team
ITA	International Transport Association
JPDO	Joint Planning and Development Office
JView	software visualization package developed by AFRL
LaRC	Langley Research Center
LNG	low noise guidance
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NGATS	Next Generation Air Transportation System
NPG	NASA Procedures and Guidelines
NRA	NASA Research Announcement
OMB	Office of Management and Budget
PARR	Problem Analysis and Resolution Ranking
PART	Performance Rating Tool
PBC	performance-based contract
PBS	performance-based services
PI	Principal Investigator
PM	Project Manager
PMT	program management tool
POC	point of contact
POP	Program Operating Plan
PS	Project Scientist
RCP	required communication performance
RNP	required navigation performance
RFI	Request for Information
RSP	required surveillance performance
RTA	required time of arrival
RTSP	required total system performance
SA	Separation Assurance
SAA	Space Act Agreement
SBIR	Small Business Innovative Research

SDO	Super-Density Operations
SLDAST	System-Level Design, Analysis, and Simulation Tools
SME	subject matter expert
TBD	to be determined
TBO	trajectory based operations
TFM	traffic flow management
TP	trajectory prediction
TPSU	Trajectory Prediction, Synthesis and Uncertainty
URET	User Request and Evaluation Tool
WBS	work breakdown structure
WebTADS	Web-based Time and Attendance System
Wx	weather
WYE	work year equivalent

APPENDIX E. WAIVERS AND DEVIATION LOG

APPENDIX F. CHANGE LOG

Revision	Description of Change	Responsible Author	Effective Date
1.0	Baseline Document	M. Landis	11/17/06
2.0	FY2008 Adjustments	M. Landis	6/26/08
3.0	FY 2009 Update. DRAFT	M. Landis	11/26/2008
3.1	Incorporate Airspace Program Office adjustment	M. Landis	12/19/2008